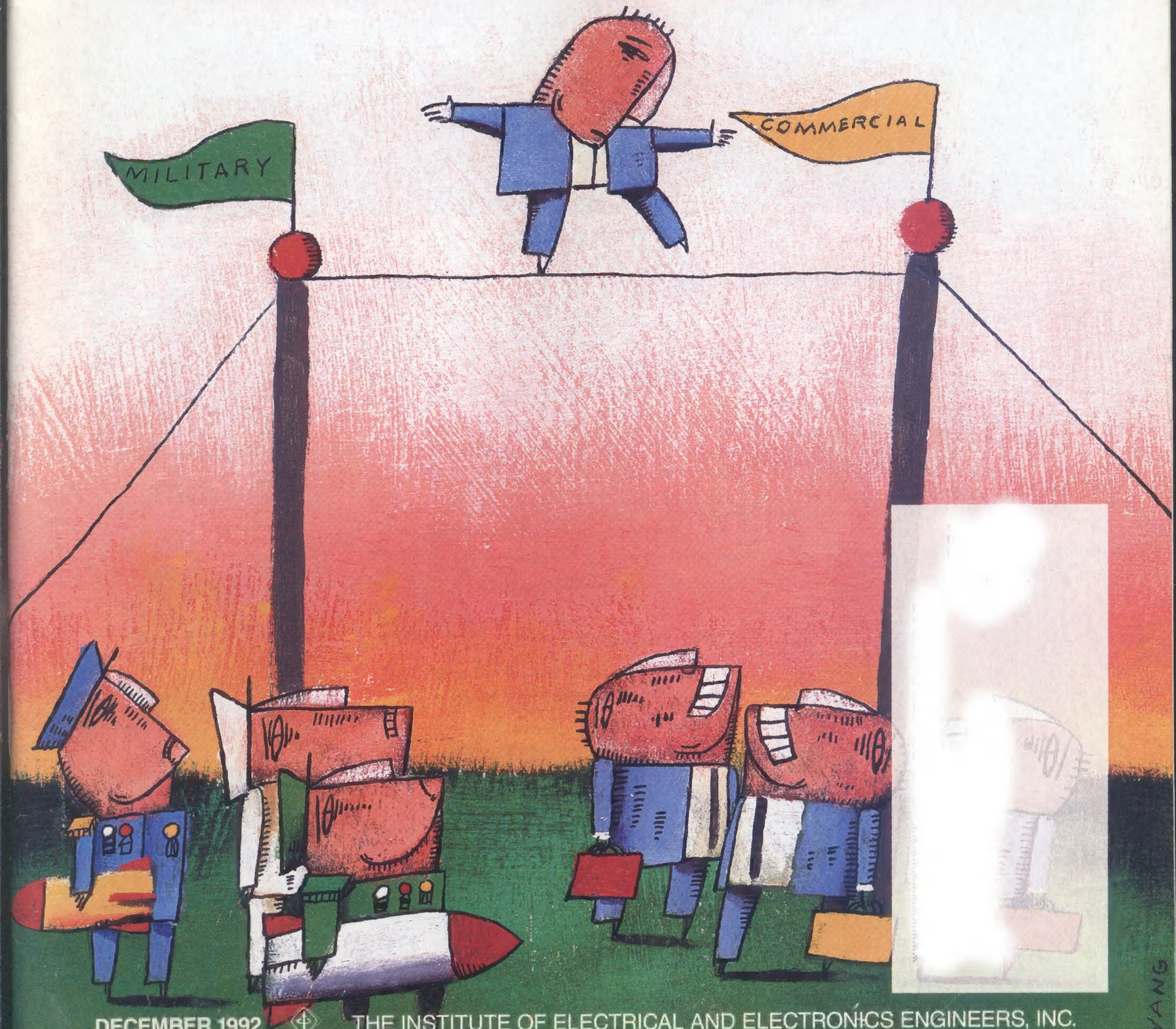
SPECIAL ISSUE

IEEE

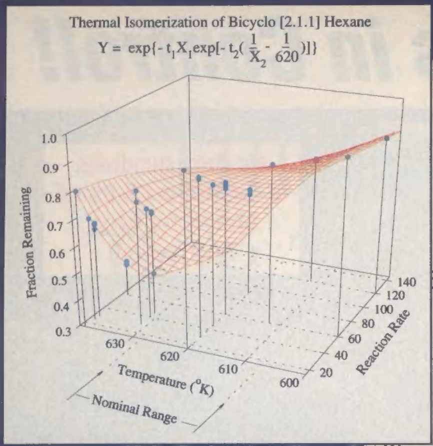
SPECTRUM

CONVERSION



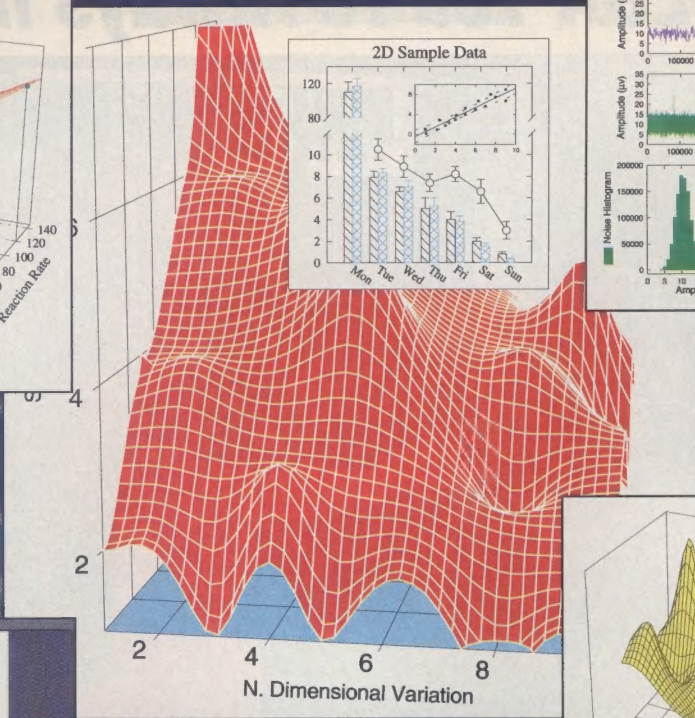
DECEMBER 1992

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

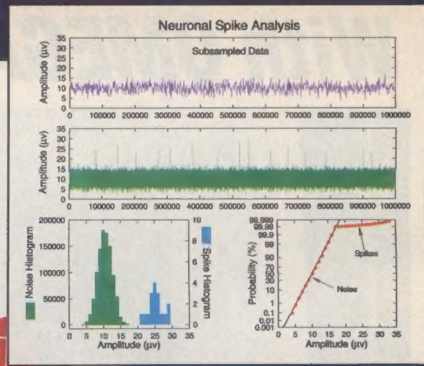


Curve fit in two, three or more dimensions! Create 3-D mesh and scatter plots. Rotate axis and tick labels to match.

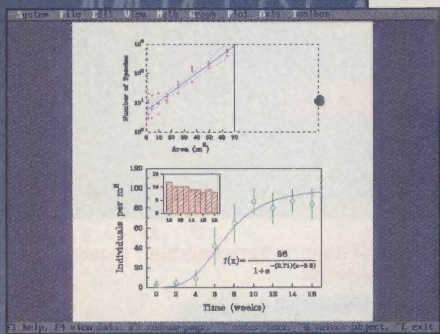
With the added feel of a desktop publisher, placing and re-sizing multiple graphs is a snap!

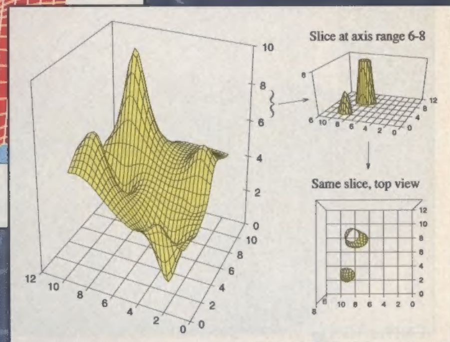


Create, overlay and inset both two- and three-dimensional graphs. Don't forget error bars, axis breaks, and time series tick labels!



Graph huge datasets! This example contains over a million data points. Note data point sampling in top graph.





Slice and rotate your 3-D graphs at will! Section data at any point and take advantage of TRUE 3-D clipping.

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NEW SigmaPlot for DOS, the choice of over 30,000 researchers world-wide for creating publication quality graphs, enters a new dimension! SigmaPlot now includes everything you need to create outstanding 2D *and* 3D graphs for lectures, poster sessions and journal publication!

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Unlike business graphics packages, SigmaPlot was designed specifically for scientists. With automatic error bars, huge dataset handling, axis breaks, regression lines, confidence intervals, non-linear curve fitting and much more. With superb output and all these specialized features SigmaPlot graphs have been published in hundreds of technical journals!

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You have nothing to lose — SigmaPlot comes with an unconditional money-back guarantee and free, unlimited technical support. Call us today and see for yourself why SigmaPlot is the #1 plotting program for scientists and engineers!

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Newslog

OCT 12. Matsushita Electric Industrial Co. said it will create and manufacture high-tech components for a U.S. project to develop what it calls the world's first personal communicator—a combination pocket cellular phone, fax machine, and pen-based computer. Matsushita will join with **AT&T Co.** and **Marubeni Corp.** in acquiring stakes in **EO Inc.**, a California-based venture company that is organizing the project.

OCT 12. New Japan Radio Co. said it will begin marketing an IC for generating chaotic patterns. The company claims the device can accomplish in moments what it now takes powerful computers hours to do. The US $42 chip should facilitate studies of the nature of chaotic phenomena and stimulate applications research in such fields as medicine and weather forecasting.

OCT 15. Intel Corp., Santa Clara, Calif., said it will begin incorporating energy-saving technology into its microprocessors, to make it easier for PCs to go into "sleep" mode when not in use. In this mode, the computers will use 30 W of electricity, compared to several hundred watts when they are "awake."

OCT 21. STC, the UK telecommunications manufacturer bought two years ago by Canada's **Northern Telecom,** said it had won a $370 million contract to build the first optical-fiber cable linking Canada and Europe. The undersea cable, due to be completed in 1994, has been commissioned by a group of international telecommunications carriers led by Teleglobe of Canada.

OCT 22. Motorola Inc., Schaumburg, Ill., and **In Focus Systems,** Tualatin, Ore., said they had launched a joint venture, **Motif Inc.,** that will by 1995 make a new kind of passive-matrix liquid-crystal display (LCD) for such products as notebook computers, wireless communications devices, and television projectors. These displays are expected to perform nearly like active-matrix LCDs, but at a fraction of the cost.

OCT 23. Nokia, the Finnish electronics group, said it has reached agreement with **Kansai Digital Phone** (KDP) to design a handheld phone for introduction to the Japanese market in 1994, when KDP will open a 1.5-GHz cellular network in the Osaka, Kyoto, and Kobe areas. Nokia is one of only two non-Japanese suppliers, alongside Motorola Inc., with a foothold in the cellular market there.

OCT 26. Japan's **Ministry of International Trade and Industry** (MITI) claimed that its environmental protection technology development program could lop 60 percent off emissions of the gases responsible for global warming by the year 2100, compared with 1985 levels. The program aims to develop solar power generators and technology to absorb CO_2 emissions from industrial plants. MITI will offer the technology to developing countries, a great source of the gases said to cause global warming.

OCT 26. The Japanese **Ministry of Posts and Telecommunications' Communications Research Laboratory** and **Ministry of Education's Institute of Space and Aeronautical Science** said they had flown a model airplane by beaming 1250-W microwaves at it from a ground-based mobile antenna. The 2-meter plane flew 20 meters above the ground for 40 seconds. Antennas on its underside picked up and sent the microwaves to rectifiers for conversion to direct current. Such beam-powered aircraft flying in the stratosphere (20–50 km above the earth) might even replace satellites in loftier orbits.

OCT 26. The **Environmental Protection Agency,** Washington, D.C., said it had issued final regulations for reducing acid rain by requiring utilities to clean up their emissions. In a revised estimate, the agency said utilities will spend $3 billion a year by the year 2000 to cut their sulfur dioxide emissions by half.

OCT 29. The **French, Belgian,** and **British rail boards** said they had unveiled their luxury 3-hour **Eurostar** service from London to Paris. The jointly managed, passenger-only service will open in 1994 and will shuttle 15 trains daily, at speeds up to 300 kph, between London and Paris and London and Brussels.

OCT 29. AT&T Co. said it would invest $402 million in a new optical-fiber system that will be the first transpacific system using optical amplifiers. The $1.12 billion TPC-5 network will be a 25 000-km loop that will link California with Hawaii, Guam, and Japan. AT&T is the lead investor with a 35 percent stake in it, and 46 other carriers from 34 countries are also investing.

NOV 2. Researchers **Arjun Yodh** and **Britton Chance** at the **University of Pennsylvania** at Philadelphia said that by measuring the angle through which a modulated laser beam was diffracted as it passed through a few centimeters of an opaque substance, they could determine variations in the substance. The technique could possibly be used to harmlessly detect tumors in breast tissue.

NOV 5. AT&T Co. said it plans to buy a 33 percent stake in **McCaw Cellular Communications,** based in Kirkland, Wash., for $3.8 billion. The pact would allow both companies to grow businesses in cellular-phone wireless communications and in personal-communications wireless services for a new generation of lightweight portable phones and handheld computers. The transaction would put AT&T in direct competition with the regional Bell companies for the first time since the 1984 breakup of the Bell system.

NOV 6. The **Environmental Protection Agency** (EPA) said it had issued final rules that will change vehicle inspection in the nation's 83 smoggiest urban areas to identify more cars that emit illegal amounts of pollution. To begin in 1995 are more sophisticated tests of car exhaust as well as new under-the-hood tests for leaks of gasoline vapors. Gasoline stations and repair shops will also be barred from performing the high-tech inspections in these areas.

NOV 9. Bellcore, Morristown, N.J., announced that it had devised a way to send movies and other video data over ordinary phone lines. The system relies on a standard established by the Moving Pictures Experts Group that shrinks the amount of information needed to store a movie in digital form by 100 times. The system, developed in conjunction with **Northern Telecom Ltd.** of Canada, parallels others now being developed, including that of Philadelphia-based **Bell Atlantic Corp.,** which will start a test system next summer.

Preview:

DEC 15. By this date, a study group set up by Japan's **Ministry of Posts and Telecommunications** expects to issue a report on how Japan should deregulate cellular phones. Under the current system, cellular phones are available only on lease from telephone system operators. Ministry officials estimated that cellular phone fees would go down by as much as 5000 yen if the phones were available for purchase on the open market.

COORDINATOR: Sally Cahur

DECEMBER 1992 Volume 29 Number 12

IEEE SPECTRUM

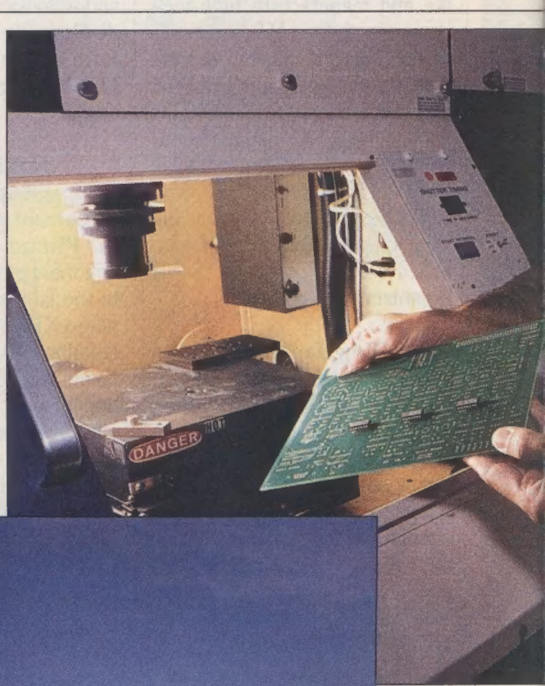
SPECIAL ISSUE

CONVERSION

Around the world, governments, companies, and engineers seek to convert to civilian products as military budgets shrink. This issue examines strategies for successful conversion and survival in a new world order.

SPECTRAL LINES

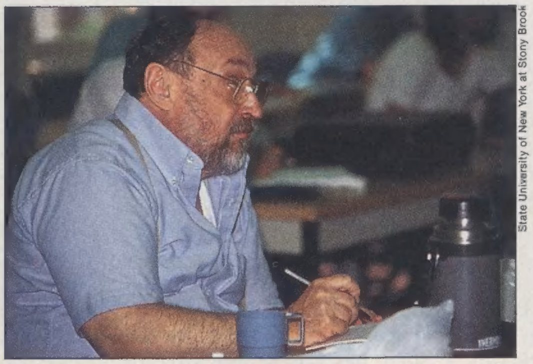
THE INSTITUTE



Metallurgist Mike Hosking helps Sandia National Laboratories transfer CFC-free laser-soldering process to commercial realm.

Hughes Network Systems

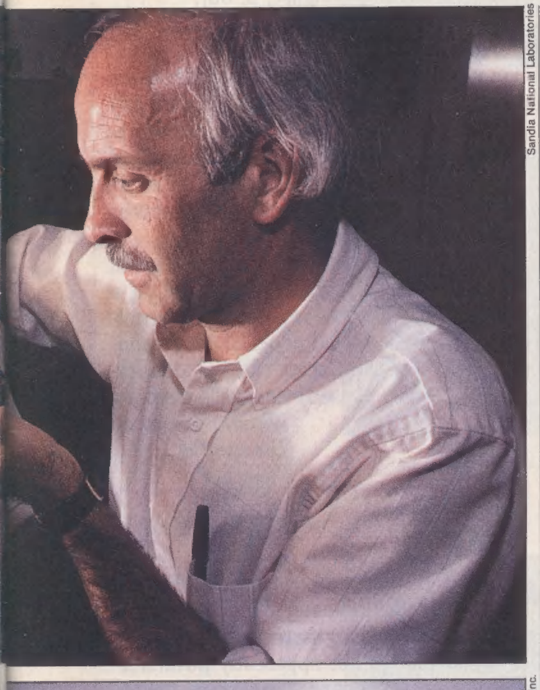
Defense giant Hughes Aircraft Co. acquired civilian antenna maker to diversify.



State University of New York at Stony Brook

Defense engineer Boris Cohen retrains in civilian technology at the State University of New York.

Israeli defense contractor Tadiran Ltd. builds automated cargo loader controls.


Sandia National Laboratories


Qualcomm Inc.

Qualcomm Inc. uses antijam radar techniques to help truckers stay in touch.


Tadiran Ltd.

Cover: An engineer gingerly walks a tightrope as military and civilian observers look on anxiously in artist James Yang's portrayal of the challenges of conversion. See. p. 26.

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Arguments and beliefs

The juxtaposition of reviews of *Galileo's Revenge* and *Searching for Certainty* [July, p. 12 and p. 14] was fortuitous. It emphasized the difference in the thought processes of the lawyer and the engineer.

From the context, I suspect neither the reviewer nor the author of *Galileo's Revenge*, Peter A. Huber, has had the responsibility for a complex engineering-related trial. The discussions, however, emphasize the benefit of being both an experienced engineer and a lawyer when handling either transactional law or trials.

As a practicing attorney, I find their thought processes sufficiently divergent to show that John Merz's comments [on *Galileo's Revenge*] substantially miss key issues—that is, engineering and science in themselves, though alleging to be exact, periodically change rules as new discoveries (or case decisions) are made. We all are aware of changes in philosophy used by the U.S. Supreme Court in interpreting law; view that in relation to the scientific analysis of the direction of electron flow, which has been redefined over the years.

I agree that spurious and far-fetched pseudoscientific arguments are frequently made on the witness stand, but nowhere near as frequently as allegedly factual evidence is distorted, bent, or simply viewed from a different perspective. It is important to differentiate between the testimony of an expert and that of a fact witness. An expert's opinion usually is based either on hypotheticals resembling the facts or on an interpretation of science or engineering. The expert generally does not testify as to the outcome of determinative events. Further, the court must accept the witness's qualifications as an expert. The fact witness, however, will give evidence based on what that person observed of the subject events.

One hopes that with a jury system, the credibility of fact and expert witnesses is reasonably assessed. As engineers, we should recognize there is no way to simply plug in objective information and elicit a response. This is not a computer operation.

Multiply the complexity by *N*, when you consider an international transaction.

Remember that the proof needed to win in a civil case is a preponderance of the evidence in favor of the plaintiff. That is translated into merely a 51 percent probability that the plaintiff is correct. In a criminal case, the standard of evidence required to establish guilt is proof beyond a reasonable doubt—again, less than 100 percent certainty.

Though we in engineering would like to say that our hypotheses or theories are provable with 100 percent accuracy, those of us who have worked with reality know better. Much of our work is predicated on theory, which is demonstrable but not provable. Theories change. Law also changes.

Law changes slowly since it requires enactment of legislatures or precedent-setting decisions of appellate courts. Law simply does not keep pace with technology, since before it can even consider the value of the technology, the technology must be published, argued, and then and only then, litigated by a party having the standing to challenge a legal issue in which the technology itself may be the issue or becomes admissible in evidence.

For purposes of transactional law or contracts, especially in international transactions, the parties should attempt to write their own law to deal effectively with potential disputes. This requires knowledge of both the law and the technology. That expertise is not easily found.

No legal system is perfect. Life is simply full of uncertainties, and the legal process is part of life.

Sidney J. Wartel
Boston

Reviewer Merz responds:
Reader Wartel's point, if I understand it, is that life itself is uncertain and we should accept that. As an engineer, I have always tried to understand how (and why) things work, to make improvements, to fix that which is broken, simply not to accept the status quo as satisfactory. Author Huber, himself an engineer, identifies a problem (which Wartel acknowledges) and offers a practicable solution.

As Wartel points out, fact witnesses and expert witnesses are different. The first testify about their observations regarding the case at hand. Expert witnesses give opinions about the case based upon their expertise and knowledge on a broader scale: upon the literature or empirical research, that is, science.

Of course, no engineer or scientist would claim that science offers to reveal "truth." There is, however, no better method than the scientific one for learning about our world and discriminating that which we "know" from that which we do not. To the extent the rogue expert scientist is willing to draw conclusions unsubstantiated by the scientific method—and burden of proof—he or she is exceeding the bounds of scientific expertise and should be barred from presenting those opinions to juries.

Ubiquitous Smith

I am fascinated by Smith charts as much as James Brittain is [August, p. 65].

The Smith chart is useful in fields ostensibly removed from electrical engineering. For example, it has been used for laser beam propagation calculations. It is commonly used to calculate and understand the properties of optical thin films. The mathematical description of propagation in thin films is virtually identical to the propagation of waves in transmission lines.

In its polar guise as a Carter chart, it can be used for stereographic projection of a sphere with the lines representing meridians and parallels of latitude. For this reason, I believe that the Carter chart is identical with the Wulff net used by crystallographers.

William Buchman
Los Angeles

Oops!

On p. 75 of the October issue, in the first column, a letter referred to electromagnetic radiation traveling faster than the speed of light. The author apparently misunderstood the concept of phase velocity—the velocity of an equiphase surface of a single-frequency wave along the wave normal—and inferred that it is the speed at which energy and/or information can be propagated.

It is not. Not mass nor energy nor information can move faster than the speed of light.

In our efforts to provide a forum for differing points of view, we clearly erred in lending credibility to an obviously erroneous notion. The guilty parties are being punished even as you read this.

As they say in Japan, sometimes even monkeys fall out of trees. *—Ed.*

Correction

In the last paragraph of the first column on p. 28 of the October issue, the city referred to should have been Colorado Springs.

—Ed.

Readers are invited to comment in this department on material previously published in *IEEE Spectrum*; on the policies and operations of the IEEE; and on technical, economic, or social matters of interest to the electrical and electronics engineering profession. Short, concise letters are preferred. The Editor reserves the right to limit debate on controversial issues. Contact: Forum, *IEEE Spectrum*, 345 E. 47th St., New York, N.Y. 10017, U.S.A.; fax, 212-705-7453.

Calendar

Meetings, Conferences and Conventions

DECEMBER

International Electron Devices Meeting (ED); Dec. 13–16; San Francisco Hilton and Towers Hotel, San Francisco; Melissa Widerkehr, Suite 610, 1545 18th St., N.W., Washington, D.C. 20036; 202-986-1137; fax, 202-347-1139.

Winter Simulation Conference—WSC '92 (C, SMC); Dec. 13–16; Crystal Gateway Marriott, Arlington, Va.; Robert C. Crain, Wolverine Software Corp., 4115 Annandale Rd., Suite 200, Annandale, Va. 22003; 703-750-3910; fax, 703-642-9634.

Conference on Decision and Control (CS); Dec. 16–18; Westin La Paloma Resort Hotel, Tucson, Ariz.; Tamer Basar, Coordinated Science Laboratory, University of Illinois, 1101 West Springfield Avenue, Urbana, Ill. 61801; 217-333-3607; fax, 217-244-1764.

JANUARY 1993

Sixth International Conference on VLSI Design (CAS, C, et al.); Jan. 3–6; Taj Intercontinental Hotel, Bombay, India; Yashwant K. Malaiya, Computer Science Department, Colorado State University, Fort Collins, Colo. 80523; 303-491-7031; or S.S.S.P. Rao, Department of Computer Science and Engineering, Indian Institute of Technology, Powai, Bombay 400076, India; (91+22) 578 2545, ext. 2701 or 2714.

International Symposium on Requirements Engineering—RE '92 (C); Jan. 4–6; Hotel del Coronado, San Diego, Calif.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

International Workshop on Modeling Analysis and Simulation of Computer and Telecommunication Systems (C); Jan. 17–20; Hyatt Regency Hotel, San Diego, Calif.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

Winter Workshop on Nonlinear Digital Signal Processing (CAS et al.); Jan. 17–20; Murikka-Opisto, Tampere, Finland; Petri Haavisto, Signal Processing Laboratory, Tampere University of Technology, Box 553, 33101 Tampere, Finland; (358+31) 161 849; fax, (358+31) 161 857.

IEEE members attend more than 5000 IEEE professional meetings, conferences, and conventions held throughout the world each year. For more information on any meeting in this guide, write or call the listed meeting contact. Information is also available from: Conference Services Department, IEEE Service Center, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855; 908-562-3878; submit conferences for listing to: Ramona Foster, *IEEE Spectrum*, 345 E. 47th St., New York, N.Y. 10017; 212-705-7305.

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(Continued on p. 22)

Cale

Meetings, Conferer

DECEMBER

International Electron Devices Meeting (ED); Dec. 13–16; San Francisco Hilton and Towers Hotel, San Francisco; Melissa Widerkehr, Suite 610, 1545 18th St., N.W., Washington, D.C. 20036; 202-986-1137; fax, 202-347-1139.

Winter Simulati '92 (C, SMC); Dec Marriott, Arlingto Wolverine Softwar Rd., Suite 200, An 750-3910; fax, 703

Conference on I (CS); Dec. 16–18;

EEs' tools & toys

Software picks and computes statistics

In evaluating real-world experiments, users must make hard decisions on which statistical procedures would be most appropriate for analyzing their data. SigmaStat not only provides the indecisive with a powerful "Advise" facility that helps them make those selections, it automatically performs the tests as well.

The software package computes such often-needed statistics as t-tests, analysis of variance, correlation, rates and proportions, nonparametric methods, linear and nonlinear regressions, power, and sample size.

Jandel Scientific claims SigmaStat is unique in its ability to process unbalanced and incomplete data sets without forcing the user to discard any data. It is based on a general linear model recently developed to handle such "messy" data sets.

The calculated descriptive statistics include mean, standard deviation, standard error of mean, maximum, minimum, normality, median, percentiles, sum of squares, skewness, and kurtosis. Also provided are several options for each test—among them: data formats, maximum order for polynomial regressions, and whether to test for normality or equal variance and acceptable *P*-value levels.

Data import options include text, spreadsheet (Lotus 1-2-3, Symphony, Excel, and Quattro), database (dBase II–IV), and SigmaPlot files. Output is a detailed report that can be edited by the user within SigmaStat and then output directly to a printer or a text file. The program also interacts directly with SigmaPlot 5.0 to create high-quality graphs.

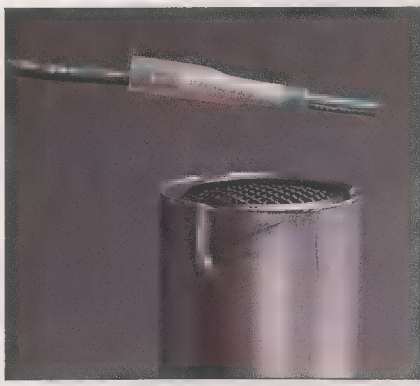
The package runs on any IBM PC or compatible computer using DOS 3.0 or higher. It requires 3 megabytes of hard disk space and 535 kilobytes of RAM (510 kilobytes if extended/expanded memory is available). Math coprocessors are supported but not required. The package sells for US $395; there is no extra charge for technical support. *Contact: Jandel Scientific, 2591 Kerner Blvd., San Rafael, Calif. 94901; 415-453-6700; or* **circle 101.**

GENERAL INTEREST

Heat-shrink wire labeling

No special printers or materials are needed in preparing custom labels, thanks to a pair of label-printing software packages and a line of wire identification labels. Designed for use with heat-shrink tubing to permanently identify wiring, the labels come in sizes from 0.90 by 0.25 inch to 1.00 by 0.94 inch for use with tubing diameters from 0.125 inch to 1.000 inch.

The packages from Panduit Corp. create labels on any IBM PC or compatible computer using DOS 3.0 or higher. Most common printer types, including lasers, are supported. Then the printed, adhesive-backed polyester label is applied to the wire, a length of heat-shrink tubing is slipped over it, and heat is applied to shrink the tubing and make the identification permanent [photo].



Panduit Corp.

To permanently mark wires from AWG 22 to AWG 1, just apply the adhesive-backed labels to a wire, slip on a length of heat-shrinkable tubing, and heat.

Free samples of the labels are available for evaluation. *Contact: Product Manager, Identification Products, Panduit Corp., 17301 Ridgeland Ave., Tinley Park, Ill. 60477-0981; 800-777-3300, ext. 7429; or* **circle 102.**

Periodic mousepad

Unlike most computer mousepads, which are, well, just mousepads, ChemPad is imprinted with the periodic table of the elements. It thus puts a useful array of data—element symbols, atomic numbers, and atomic weights to five significant figures—literally at any user's fingertips.

The pad measures 232 by 197 mm and is imprinted using a dye sublimation process instead of the usual silk-screening. Because of that process, the imprinting is guaranteed for the life of the pad, according to Cirrus Technology.

ChemPad retails for US $14.95 plus shipping and handling; it is available from stock. Discounts are offered for quantities of 10 or more. *Contact: Cirrus Technology, 49 Midgley Lane, Worcester, Mass. 01604; 508-755-5242; fax, 508-795-1636; or* **circle 103.**

(Continued on p. 22)

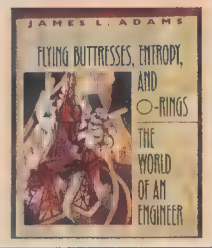
Books

Building the future (or, why I became an engineer)
Mario Salvadori

The author of this book is an engineer's engineer: a professional, consulting engineer and professor. Although he modestly says his readers will "find more things mechanical than electrical or chemical" in his book, he actually discusses all facets of most engineering fields, from conception through design, manufacturing, testing, business practices, and codes. He adds that he wrote "for non-engineers," including those "thinking of becoming engineers."

Of all the youngsters entering the school systems of the United States, 99.5 percent choose not to become practicing engineers. This situation endangers our technical preeminence in today's competitive, interconnected world and threatens the stability of our economy. Yet it is not surprising. Engineers are undervalued and underpaid in a society that recognizes the individual's value mostly through financial compensation. Moreover, the general populace of the United States seems plagued by a phobia for mathematics and science, which is understandable up to a point and partly attributable to the country's varied population and intensely pragmatic traditions. Thus, Adams's book is a most welcome addition among books seeking to popularize engineering.

Flying Buttresses, Entropy, and O-Rings: The World of an Engineer.
Adams, James L., Harvard University Press, Cambridge, Mass., 1991, 264 pp., $24.95.



The opening chapter is a very condensed history of technology, from 5000 BC to the present, replete with nuggets of the most recent discoveries of archeological research. The second explains "the complexity of engineering, its specialties, its uses of math and science and its business practices." The next goes into the tensions and the give-and-take between research and application in engineering.

The following three chapters deal with the inventive facet of the profession (which the author seems to consider both essential and more common than do most other engineers), the engineering uses of applied mathematics, and scientific principles important to engineering. Adams assumes familiarity with concepts taken from elementary algebra up through vector calculus, and expounds upon thermodynamics, entropy, and even the uses of deoxyribonucleic acid (DNA).

Testing procedures come next, from those for a simple spring to those for the O-rings of the doomed Challenger space shuttle. There are also discussions of what caused the crash of a DC-10 and the collapse of the walkway at the Hyatt Regency Hotel in Kansas City, Mo.

The evolution of manufacturing and assembling is the next topic. Beginning with Renaissance armaments technology, the author progresses toward the robotic assembly of automobiles and the design and fabrication of semiconductor integrated circuits. There is also a chapter on

Circle No. 10

Books

the conflicting forces behind government regulations.

The 11th and final chapter, titled "The Challenge for the Future," pleads for the abandonment of "the old laissez-faire approach to technology" and predicts a return to a safe nuclear energy program. Adams wisely refuses to speculate about the future of engineering, but emphasizes the importance of scientific and technical literacy on the part of the general public. He well knows that the evolution of a much-needed, technologically oriented educational system will encounter difficulties and take longer than most experts suggest.

The book is beautifully designed and printed, lavishly illustrated, comprehensive, clearly written and often witty, and it even includes a rich, valuable bibliography. It would be unmatched among the books dedicated to spreading information about engineering to non-engineers—except for two problems. For one, its 264 pages are a bit much for a general-interest introduction to engineering. The more serious obstacle to wide popularity, however, is the depth and technical nature of the book's presentations.

This would not matter for *IEEE Spectrum*'s readers, but it makes *Flying Buttresses* unreadable by most of today's high school students and even many college students who might otherwise be inspired by it to consider an engineering career. I suspect that the book will be enjoyed mostly by engineers in one of our 42 specialties who are curious to find out what their colleagues in the other 41 are up to. Adult non-engineers interested in technology history and recent developments may also be fascinated.

If I could ask the author for one more thing, it would be for a sequel to this wonderful book, written for today's high school youngsters. Unaware as they are of what engineering is and has to offer them, they need such an introduction far more than the minority of interested college students and well-educated adults. For the author, such a book would be a fine achievement and a great service to his country.

Mario Salvadori, an engineer and mathematical physicist, is the James Renwick Professor Emeritus of civil engineering and professor emeritus of architecture at Columbia University in New York City. He is also honorary chairman of the Salvadori Educational Center on the Built Environment, dedicated to the math and science education of primary and secondary school students, mostly in underprivileged areas in the United States.

COORDINATOR: Glenn Zorpette

Recent books

Neural Network Parallel Computing. *Takefuji, Yoshiyasu*, Kluwer Academic, Norwell, Mass., 1992, 230 pp., $65.

Microcontrollers: Architecture, Implementation, and Programming. *Hintz, Kenneth J.*, and *Tabak, Daniel*, McGraw-Hill, New York, 1992, 483 pp., $44.95.

Teleoperation: Numerical Simulation and Experimental Validation. Ed. *Becquet, Marc C.*, Kluwer Academic, Norwell, Mass., 1992, 258 pp., $98.

Introduction to Operational Amplifier Theory and Applications, 2nd edition. *Wait, John V., et al.*, McGraw-Hill, New York, 1992, 380 pp., $58.29.

The Basics of Business Writing. *Stuckey, Marty*, Amacom, New York, 1992, 80 pp., $10.95.

BASICs for DOS. *Cornell, Gary*, Windcrest/McGraw-Hill, Blue Ridge Summit, Pa., 1992, 432 pp., $31.95.

Oversampling Delta-Sigma Data Converters. *Candy, James C.*, and *Temes, Gabor C.*, IEEE Press, New York, 1992, 300 pp., $69.95.

Awards 92

Alon Orlitsky photo:

Alon Orlitsky will receive the W.R.G. Baker Prize Award for his paper "Worst-Case Interactive Communication I: Two Messages are Almost Optimal," published in the *IEEE Transactions on Information Theory,* Vol. 36, No. 5, September 1990, pp. 1111–26. The paper considers the number of bits that must be transmitted in the worst case when a person P_x wants to convey some information X to a person P_y who has related information Y, and relates how this number of bits is affected when the communicators are allowed to interact. Presentation of the award will be made at the International Symposium on Information Theory, San Antonio, Texas, on Jan. 21, 1993.

Orlitsky has been employed since 1986 in the communications analysis research department at AT&T Bell Laboratories, Murray Hill, N.J., where he is working on theoretical aspects of communication and computation. He holds a Ph.D. in electrical engineering from Stanford University in California, which he received in 1986. That university also awarded him a Master's degree. He received Bachelor of Science degrees in mathematics and electrical engineering from Ben Gurion University in Be'er Sheva, Israel, in 1980 and 1981, respectively.

Prize papers

Anthony Ephremides

Sergio Verdú

Anthony Ephremides (F) and **Sergio Verdú** (SM) share the 1992 Donald G. Fink Award for their paper "Control and Optimization Methods in Communication Network Problems," published in *IEEE Transactions on Automatic Control*, Vol. 34, No. 9, September 1989, pp. 930–42. They will receive the award on Dec. 17 at the IEEE Conference on Decision and Control, Tucson, Ariz.

Ephremides is a professor at the University of Maryland's Systems Research Center in College Park, which he helped found in 1985 and which is funded by the National Science Foundation. He is also co-director of the recently established Center for Commercial Development of Space for Hybrid and Satellite Communication Networks, also at the university, which is funded by the National Aeronautics and Space Administration. His research interests have evolved from statistical communication theory to communication networks and encompass such areas as queueing networks, digital communications, stochastic systems, optimization, protocol design, and distributed and discrete-event systems. Currently his work emphasizes wireless communication networks, as well as specialized system design for meteor-burst channels, indoor radio networks for manufacturing systems, and satellite networks at K_a band.

Ephremides received a Bachelor of Science degree in electrical engineering from the National Technical University in Athens, Greece, in 1967. He then continued in graduate studies at Princeton University in New Jersey, where he obtained Master's and Ph.D. degrees in 1969 and 1971, respectively.

Verdú is an associate professor of electrical engineering in the department of electrical engineering and computer science at Princeton. He has contributed to the understanding of several problems having to do with information systems: multi-user detection, minimax robustness in communications and control, channel equalization, random-access algorithms, optical channels, dynamic programming, and computational complexity. His current interests are primarily in information theory.

Verdú received a degree in telecommunication engineering from the Polytechnic University of Barcelona in Spain in 1980. He pursued graduate studies sponsored by a Fulbright Scholarship and an IBM Fellowship at the Coordinated Science Laboratory of the University of Illinois at Urbana-Champaign. There he received his Ph.D. degree in electrical engineering in 1984. At Princeton, he has taught courses on information theory, communication systems, random processes, data networks, and discrete systems.

Bertrand S. Clarke

Andrew R. Barron

Bertrand S. Clarke (M) and **Andrew R. Barron** (M) share the Browder J. Thompson Memorial Prize Award for their paper "Information-Theoretic Asymptotics of Bayes Methods," *IEEE Transactions on Information Theory,* Vol. 36, No. 3, May 1990, pp. 453–71. The award, made to authors 30 years of age or under, will be presented on Jan. 21 at the 1993 International Symposium on Information Theory, San Antonio, Texas.

Clarke is an assistant professor in the department of statistics at Purdue University, Lafayette, Ind. He earned a Ph.D. in statistics at the University of Illinois at Urbana-Champaign in 1989. His Bachelor of Science degree in pure mathematics and theoretical statistics was awarded by the University of Toronto in 1984. The work that led to the paper was done while Clarke was a research assistant to Barron, from 1985 to 1989, at the University of Illinois.

Barron has been at the University of Illinois since 1985, as an assistant professor in the statistics and electrical and computer engineering departments and as a research associate professor in the university's Coordinated Science Laboratory. He earned Master of Science and Ph.D. degrees in electrical engineering from Stanford University in California in 1982 and 1985, respectively. Earlier, in 1981, he received a Bachelor of Science degree in electrical engineering and mathematical science from Rice University in Houston, Texas.

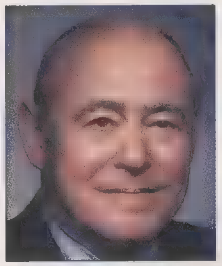
In their work, Clarke and Barron took a target probability distribution for sequences of random variables and used it to derive the asymptotics of the entropy distance of a Bayesian probability distribution. Moreover, they explored the relationship between the redundancy of universal source codes for data compression, the cumulative risk of Bayes estimators, and the asymptotic normality of Bayesian posterior distributions. Applications were also given for performance bounds for tests of composite statistical hypotheses and for stock market portfolio selection.

IEEE service awards

Richard James Backe (SM), program director of Paramax Corp./Goddard Facility, a Unisys Co. in Lanham, Md., received the Haraden Pratt Award "for dedication to the professional needs of the employed engineer, and to the broader technical and educational goals of the IEEE."

At the Paramax-Goddard facility, Backe manages the technical and business aspects of 16 departments staffed by 300 engineers and scientists. Their work includes failure analyses of complex devices, standards and metrology, and audits of spacecraft hardware and software.

Backe, active in the IEEE since 1960, contributed early on to the Parts and Hybrid Group, for which he co-edited the *PHP Transactions*. He helped in forming the United States Activities Board (USAB), then known as the U.S. Activities Committee, and in founding the IEEE office in Washington, D.C. He was vice chairman of USAB; chaired many USAB committees, including Employment Assistance, Pension, Government Affairs, and Congressional Fellows; and was a member of many others. His testimony before committees of Congress helped bring about the 1974 Pension Reform bill. He also edited the Institute's "Employment Guide for Engineers and Scientists."

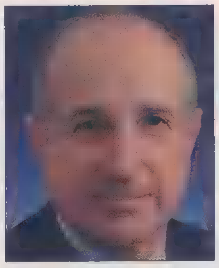


Bruno O. Weinschel (LF), chief engineer of Bruno Weinschel Associates and president of Weinschel Research Foundation Inc., both based in Gaithersburg, Md., received the Richard M. Emberson Award "for distinguished leadership in the Institute's technical, professional, educational, standards, and publishing activities."

A Past President of the IEEE, Weinschel was from 1943 to 1944 a supervisory engineer of electrical test planning at the Bell System. From 1944 to 1948, he was chief engineer of Industrial Instruments, and from 1949 to 1952, section chief at the National Bureau of Standards (now the National Institute of Standards and Technology), Gaithersburg, Md. From 1952 to 1986, Weinschel was chief engineer of Weinschel Engineering Co., continuing as a consultant during 1987–88. His IEEE positions have included Vice President for Professional Activities (1978–79), Secretary (1980), and President (1986).

At the Standards Board in 1989, as chairman of the strategic planning committee, Weinschel played a strong role in a major reorganization of the Board. While serving on the Publications Board in 1988, he was a leading proponent of moving to compact-disc ROM publications.

Engineering Leadership



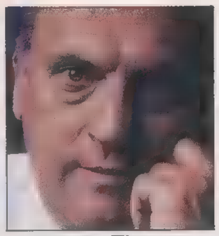
Bernard M. Gordon (F), president, chief executive officer, and chairman of the board of Analogic Corp., Peabody, Mass., was awarded the IEEE Engineering Leadership Recognition because "through his bold leadership, his many inventions, and his innovative entrepreneurial activities, he has been a prime contributor to the growth of electro-technology."

Gordon is best known for pioneering inventions in high-speed digital signal processing. He holds nearly 100 U.S. patents relating to the development of a vast array of devices, including early successive-approximation analog-to-digital converters, dot-matrix cathode-ray tube displays, digital plan-position indication (PPI) radars, fetal heart monitors, pulse-code modulation telemetry systems, music digitizing and recording systems, and instant imaging.

Early in his career, in 1947, Gordon joined Eckert-Mauchly, where he worked on the Univac I computer. In 1954, he co-founded Epsco Inc. to develop high-speed analog-to-digital conversion. He founded Gordon Engineering Co., the forerunner of Analogic, in 1963. In 1984, he founded The Gordon Institute in Wakefield, Mass., a graduate school devoted to the development of engineering leaders.

Corporate Innovation

Lars Ramqvist



Jan D. Timmer

Ericsson Radio Systems AB and **Philips Electronics NV** received IEEE Corporate Innovation Recognitions.

Ericsson Radio of Stockholm, Sweden, was recognized "for significant contributions to the development and implementation of analog and digital cellular radio technology." The company has pursued R&D and manufacturing of telecommunication systems, services, and applications since 1876. By merging radio and switching technology, Ericsson has become the world's largest supplier of analog cellular radio systems. Ericsson also developed a standardized spectrum-efficient digital cellular radio concept based on time-division multiple-access technology, and the company has been a pioneer in developing cellular and advanced wireless communications systems. The Recognition was accepted by Lars Ramqvist, the company's president and chief executive officer.

Philips of Eindhoven, the Netherlands, was recognized "for pioneering research in electronics and the development of much of the basic technology leading to the creation of the optical recording industry." Philips was founded by Gerard Philips in 1891 to manufacture light bulbs.

Today, the company describes itself as a transnational, industrial, diversified electronics organization with research laboratories in five countries and nearly 300 factories in 46 countries. It has its own national sales organization in 60 countries, marketing and service outlets in 150 countries, and a multicultural workforce of about 240 000 employees. With sales of US $30.8 billion in 1990, Philips ranked 28th on the *Fortune* magazine list of the world's largest industrial companies. It spends about 7 percent of its annual sales on research and development. Philips inventions have become household words—two examples are the compact audiocassette and the compact disc. The Recognition was accepted by Philips president Jan D. Timmer.

Honorary Membership

Mark Krivocheev (HM), professor of technical science and head of the scientific department on television in the Radio Research Institute, Moscow, was made an Honorary Member of the IEEE "for technical contributions to television and leadership in developing international standardization."

In 1946, Krivocheev designed a scanning unit that led to the first realization of a 625-line raster. He then headed the studio production complex for the Moscow TV center, inaugurating in 1948 the first 625-line transmission. Krivocheev founded and headed the Russia School for TV Measurement. Alone or with others, he holds or has developed more than 90 patents and inventions in TV technology and is the author of many technical papers and books. Krivocheev has served on the International Radio Consultative Committee (CCIR) of the International Telecommunication Union, Geneva, since 1948, and as chair since 1974, has led the committee's work in digital television and high-definition television. ◆

Calendar

(Continued from p. 8)

International Symposium on Information Theory (IT); Jan. 18–22; Hilton Palacia del Rio, San Antonio, Texas; Galen H. Sasaki, Department of Electrical and Computer Engineering, Engineering Science Building, University of Texas at Austin, Austin, Texas 78712-1084; 512-471-6734; fax, 512-471-5532.

International Conference on Wafer Scale Integration (C, CHMT); Jan. 20–22; Fairmont Hotel, San Francisco; R. Mike Lea, Brunel University, Uxbridge, England UB8 3PH; (44+895) 203 221; fax, (44+895) 258 728.

Ultrafast Electronics and Optoelectronics Topical Meeting (ED); Jan. 25–27; Hyatt at Fisherman's Wharf, San Francisco; Optical Society of America, 2010 Massachusetts Ave., N.W., Washington, D.C. 20036; 202-223-0920; fax, 202-416-6100.

Annual Reliability and Maintainability Symposium–RAMS (R); Jan. 26–28; Westin Peachtree Hotel, Atlanta, Ga.; V.R. Monshaw, Consulting Services, 1768 Lark Lane, Cherry Hill, N.J. 08003; 609-428-2342.

Power Engineering Society Winter Meeting (PE); Jan. 31–Feb. 5; Hyatt Regency Hotel, Columbus, Ohio; T.C. Wong, American Electric Power Service Co., One Riverside Plaza, Columbus, Ohio 43215; 614-223-2235; fax, 614-223-2205.

FEBRUARY

Ninth Semiconductor Thermal Measurement and Management Symposium—Semi-Therm (CHMT); Feb. 2–4; Four Seasons Hotel, Austin, Texas; Alfonso Ortega, University of Arizona, Department of Aerospace and Mechanical Engineering, Tucson, Ariz. 85721; 602-621-6787; fax, 602-621-8191.

Workshop on VLSI (C); Feb. 7–10; Asilomar Conference Center, Monterey, Calif.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

Wattec '93 (Oak Ridge Chapter); Feb. 16–19; Hyatt Regency Hotel, Knoxville, Tenn.; John W. Shipp Jr., Tennessee Valley Authority, 601 W. Summitt Hill, OCH 1E, Knoxville, Tenn. 37902; 615-632-6426.

Optical Fiber Communication/International Conference on Integrated Optics and Optical Fiber Communication (COM, LEO); Feb. 21–26; San Jose Convention Center, San Jose, Calif.; IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3895; fax, 908-562-1571.

International Solid-State Circuits Conference (SSC et al.); Feb. 24–26; San Francisco Marriott Hotel, San Francisco; Diane S. Suiters, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-639-4255; fax, 202-347-6109.

Second Annual Conference on Evolutionary Programming (NN); Feb. 25–26; Radisson Hotel, La Jolla, Calif.; David B. Fogel, 9363 Towne Centre Dr., San Diego, Calif. 92121; 619-455-5530, ext. 424; fax, 619-453-9274.

MARCH

Third Great Lakes Symposium on VLSI (C, CAS); March 5–6; Western Michigan University, Kalamazoo; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

ANSYS®-PC/Magnetic

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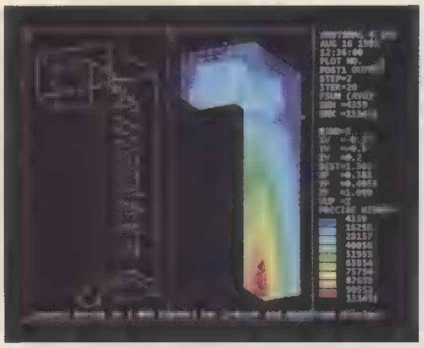
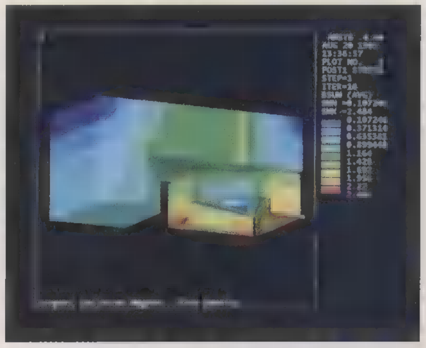
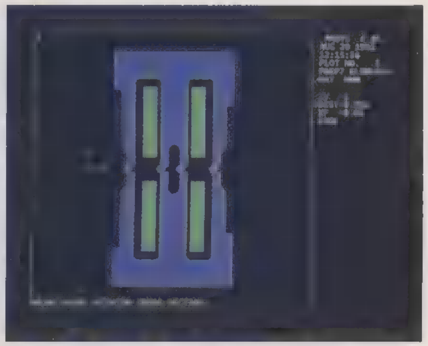


ANSYS magnetics was used by Stone and Webster Engineering Corporation with MIT Plasma Fusion Center to analyze the conductors, iron mass, and field in [redacted] MHD channel. Displayed are the Lorentz forces in a conductor.



Magnetic field analysis for a cyclotron magnet design was performed by the National Superconducting Cyclotron Laboratory, Michigan State University, using [redacted] magnetics to determine flux density levels.



A printer head linear actuator device [redacted] modeled by IBM Corporation [redacted] evaluate normal end axial forces [redacted] a sliding armature situated between [redacted] stators.

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- Current Sources
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- External Field Excitation
- Skin Effects

FIELD SIMULATION 3-D:

- Static Analysis
- AC Analysis
- Transient Analysis
- Saturable Irons
- Current Source Primitives
- Permanent Magnets
- External Field Excitation
- Electro-magnetostatic Coupling

Circle No. 31

Calendar

(Continued from p. 18)

Applied Power Electronics Conference and Exposition—APEC '93 (IA, PEL); March 6–12; Town and Country Hotel, San Diego, Calif.; Virginia Insley, Courtesy Associates, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-639-4990.

Multi-chip Module Conference (ED); March 15–18; Cocoanut Grove, Santa Cruz, Calif.; S. Simon Wong, CIS-202, Stanford University, Stanford, Calif. 94305-4070; 415-725-3706; fax, 415-725-6949.

19th Annual Northeast Bioengineering Conference (EMB); March 18–19; New Jersey Institute of Technology, Newark; Stanley Reisman, ECE Department, New Jersey Institute of Technology, Newark, N.J. 07102; 201-596-3527.

International Conference on Microelectronic Test Structures (ED); March 22–25; Gran Sitges Hotel, Barcelona, Spain; Loren W. Linholm, National Institute of Standards and Technology, B360 Technology Building, Gaithersburg, Md. 20899; 301-975-2052; fax, 301-948-4081.

International Reliability Physics Symposium (ED); March 22–25; Hyatt Regency Hotel, Atlanta, Ga.; David A. Baglee, 5604 Cometa Court N.E., Albuquerque, N.M. 87111; 505-893-3446; fax, 505-893-1049.

Topical Symposium on Combined Optical-Microwave Earth and Atmosphere Sensing (LEO); March 22–25; Hyatt Regency Hotel, Albuquerque, N.M.; IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3894; fax, 908-562-1571.

Second International Workshop on Software Reusability—IWSR-2 (C); March 24–26; Villa Bottini, Lucca, Italy; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

International Conference on Neural Networks—ICNN '93 (NN); March 28–April 1; San Francisco Hilton, San Francisco; Nomi Feldman, Meeting Management, 5665 Oberlin Dr., Suite 110, San Diego, Calif. 92121; 619-453-6222; fax, 619-535-3880.

Second International Fuzzy Systems Conference (NN); March 28–April 1; San Francisco Hilton, San Francisco; Nomi Feldman, Meeting Management, 5665 Oberlin Dr., Suite 110, San Diego, Calif. 92121; 619-453-6222.

International Symposium on Autonomous Decentralized System (C); March 30–April 1; Hitachi System Plaza, Kawasaki, Japan; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

APRIL

International Conference on Indium Phosphide and Related Materials (ED); April 18–22; Maison de la Chimie, Paris, France; Susan Evans, IEEE/LEOS, 445 Hoes Lane, Piscataway, N.J. 08855-1331; 908-562-3896; fax, 908-562-1571.

Second Annual Symposium on Document Analysis and Information Retrieval (C); April 26–28; Caesars Palace Hotel, Las Vegas, Nev.; William L. Brogan, University of Nevada, 4505 Maryland Parkway, Las Vegas, Nev. 89154-4026; 702-597-4183.

(Continued on p. 18F)

Engineers for Education Needs Volunteers

An education goal of the United States is to make American students first in the world in mathematics and science achievement by the year 2000. "Engineers for Education" (E for E) is the engineering community's response to this goal.

IEEE and 40 other national engineering societies pledged to enlist 100,000 volunteer engineers to assist and support teachers of math and science in elementary and secondary schools in the United States. During a White House ceremony in 1991, President Bush helped inaugurate E for E and accepted a scroll signed by the presidents and executive directors of the societies.

Now we are ready to move ahead with recruiting engineer volunteers. During the preparatory phase, more than 5,000 people called our toll-free hotline, and more than 1,000 volunteers are either in or available to work in schools. While this is a start, we have a long way to go to reach our goal of 100,000 volunteers.

As an IEEE member, you are uniquely qualified to serve as a role model for students and a resource for teachers. You can bring the excitement of math, science and engineering into an elementary or high school classroom. To help you establish an on-going partnership with teachers in a school in your area, E for E will send you a planning kit with information on a number of programs you can use.

We have a long way to go to meet our pledge of 100,000 volunteers. Our nation's children need your help. You may volunteer or contribute in other ways by calling E for E at 1 (800) 489-0348, or by writing to Engineers for Education, 370 L'Enfant Promenade, 10th Floor, Washington, DC 20024-2518. Help us help America's children become "Second to None . . . First in Math and Science by 2000."

—*Lawrence P. Grayson,* President
Engineers for Education

Circle No. 25

From My Perspective

In my previous editorial I addressed "the dilemma of democracy." (See insert in *The Institute*, Sept./Oct. 1992.) I suggested that IEEE's top leaders should reflect the will of members, but I also noted that often what members want is not good for them.

Some interesting responses came from readers. One member wrote that members have had too much activity forced on them, with the excuse that it is good for them and that the hierarchy knows best. "This is an insult to the intelligence of IEEE members and reveals the cloistered, if not arrogant, attitude of the leaders," he said.

Another member asked, "As the defense budget shrinks, what happens to engineers who have dedicated years to this industry?" He surmises that until engineers are retrained for new jobs and new jobs are created, we will have an EE surplus, making "a sham" of studies indicating that we will suffer a shortage of engineers.

Perhaps IEEE's leaders should refocus their attention on important matters affecting the welfare of the majority of members—the professional EEs who are U.S. residents. Instead, our leaders tamper with the budget development process. Do life members really need to pay dues? Or, our leaders meddle with the democratic rules governing elections. Do members want a President who could not be elected, except by changing the rules?

I challenge IEEE's leaders to help U.S. members in distress by lobbying national leaders to implement the Full Employment and Balanced Growth Act of 1978. The peace dividend could fund it. The Act provides for the Federal Government to use all practical means to promote full employment and production, increase real income, ensure adequate productivity growth, and improve international competitiveness.

I also challenge IEEE leaders to explore the feasibility of establishing a private unemployment insurance plan for members, just as IEEE has arranged other insurance plans for members.

For more information on the Full Employment and Balanced Growth Act, write to me in care of the IEEE-USA Office in Washington, D.C. Comments from readers are always welcome.

—*Michael J. Whitelaw,* P.E.
Editor in Chief

Coping With Ethical Dilemmas in the Workplace

Consider this scenario, furnished by an engineer with 20 years' experience.

You are a test engineer and have just determined that the product lot manufactured for customer A failed one of several reliability tests specified by the customer. Your boss is under pressure to ship these units to customer B, who does not require this particular test. Your boss expects you to sign off the lot as "representative product" and ship them to customer B. What do you do?

How can you survive ethically in a world that is highly competitive, often intense, and driven by the profit motive? Help is available.

IEEE-USA's Ethics Committee serves U.S. members in the practical interpretation of IEEE's Code of Ethics and helps them deal with ethics issues before they become critical dilemmas. The Committee is prepared to offer timely, non-legal advice, including referrals to appropriate IEEE entities, such as the Member Conduct Committee, or even an outside agency. Sometimes it may be helpful just to talk things over with another engineer, one sensitive to ethical problems and experienced in resolving them.

To make use of this confidential service, contact Scott Grayson at the IEEE-USA Office in Washington, D.C. ✦

Job Fairs Update

IEEE Job Fairs are tentatively scheduled at these locations during December 1992 and January, February, and March 1993.

DATE	LOCATION
December 7-8	Chicago Section
January 18-19	Chicago Section
January 18-19	Nat'l. Capital Area Council
January 19-20	Boston Section
February 17-18	Detroit Section
February 22-23	Dallas Section
March 8-9	Nat'l. Capital Area Council
March 22-23	Boston Section

Job Fairs are open to all engineers. To locate the Fair nearest you, contact the IEEE Career Fairs Coordinator at (800) 562-2820; in Virginia, call (800) 533-1827. ✦

Circle No. 26

How Will Your Salary Compare?

In January 1993, ten percent of IEEE's U.S. members will receive a salary survey questionnaire. This survey will address the key issues of today's economy, with questions about engineering employment, salaries, and benefits.

If you receive the questionnaire, we urge you to complete and return it by the deadline requested. Over the years that IEEE has conducted the salary survey, the data have proven invaluable to many individuals, companies, and libraries that purchase this important reference document.

IEEE members will be able to obtain a copy of the survey for a special rate of $74.95, plus shipping and handling, by calling 1 (800) 678-IEEE and asking for IEEE Catalog Number UH0194-1; or write to IEEE's Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331. The nonmember price is $99.95, plus tax and shipping.

—*Roy Harris*, Chairman
Salary Survey Committee

Student Edition of Employment Guide Now Available

IEEE-USA has published the second edition of the student version of *The Employment Guide for Engineers and Scientists.* Volume One of the two-volume set covers basic information on conducting a job search, writing a resume, and developing a network to assist in the job search process. Special features include the 50 most-asked questions in an interview and a chapter on evaluating compensation packages. The second volume is a directory of employers of IEEE members, listing hundreds of companies by state, including addresses, telephone numbers, and contact persons.

The student edition of the *Guide* may be ordered by calling 1 (800) 678-IEEE and asking for IEEE Catalog Number UH0188-3; or writing IEEE's Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331. Prices are $14.95 for members and $19.95 for nonmembers, plus tax and shipping. ✦

Circle No. 27

That Volunteer Deserves A Medal!

How many times have you thought that IEEE-USA volunteers deserve some sort of reward for all the work they do to promote professional activities? Well, here's your chance to make that happen. Nominations for the 1993 United States Activities Board (USAB) awards are now open.

USAB's awards program is the only one in the Institute to select recipients solely on the basis of accomplishments in professional, non-technical activities, as defined by the IEEE Constitution.

In addition, USAB's awards include two for literary contributions and the Harry Diamond Memorial Award for technical contributions to the electrotechnology field while in U.S. Government service.

Nomination forms and further information are available from the IEEE-USA Office in Washington, D.C., where completed forms should be returned by March 31, 1993. ✦

Circle No. 28

IEEE United States Activities

Announces the 21st Annual Competition for

1993-1994 Congressional Fellowships

PROGRAM: Electrical and Electronics Engineers and Allied Scientists are competitively selected to serve a one-year term on the personal staff of individual Senators or Representatives or on the professional staff of Congressional Committees.

PURPOSE: To make practical contributions to more effective use of scientific and technical knowledge in government, to educate the scientific communities regarding the public policy process, and to broaden the perspective of both the scientific and governmental communities regarding the value of such science-government interaction.

CRITERIA: Fellows shall be selected based on technical competence, on ability to serve in a public environment, and on evidence of service to the Institute and the profession. Specifically *excluded* as selection criteria are age, sex, creed, race, ethnic background, and partisan political affiliations. However, the Fellow must be a U.S. citizen at the time of selection and must have been in the IEEE at Member grade or higher for at least four years.

AWARDS: IEEE-USA plans to award at least two Congressional Fellowships for the 1993-1994 term.

APPLICATION: Further information and application forms can be obtained by calling W. Thomas Suttle, (202) 785-0017, at the IEEE-USA Office in Washington, D.C., or by writing:

Secretary, Congressional Fellows Program
IEEE United States Activities
1828 L Street, N.W.
Washington, D.C. 20036-5104

Applications must be postmarked no later than March 31, 1993 to be eligible for consideration.

Circle No. 29

Calendar

(Continued from p. 18B)

International Conference on Acoustics, Speech and Signal Processing (SP); April 27–30; Minneapolis Convention Center, Minnesota; Mostafa Kaveh, Department of Electrical Engineering, University of Minnesota, 200 Union St., S.E., Minneapolis, Minn. 55455; 612-625-0720.

MAY

Power Industry Computer Applications Conference (PE); May 4–7; Omni Adams Hotel, Phoenix, Ariz.; Denny Brown, Arizona Public Service Co., Box 53999, Mail Station 8962, Phoenix, Ariz. 85072-3999; 602-250-3133.

Custom Integrated Circuits Conference (ED); May 9–12; Town and Country Hotel, San Diego, Calif.; Roberta Kaspar, 1597 Ridge Rd. West, Suite 101C, Rochester, N.Y. 14615; 716-865-7164; fax, 716-865-2639.

Photovoltaic Specialists Conference (ED); May 10–14; Galt House, Louisville, Ky.; Eldon C. Boes, National Renewable Energy Laboratory, Suite 710, 409 12th St., S.W., Washington, D.C. 20024; 202-484-1090; fax, 202-484-8177.

15th Annual Electronics Exposition and Symposium (Albuquerque Section); May 11–13; Albuquerque Convention Center, New Mexico; Meridee Katz, ISE Exposition Manager, 8100 Mountain Rd., N.E.–109, Albuquerque, N.M. 87110-7827; 505-262-1023.

International Symposium on VLSI Technology Systems and Applications (ED); May 12–14; Lai Lai Sheraton, Taipei, Taiwan; Genda J. Hu, Cypress Semiconductor, MS/1-1, 3901 N. First St., San Jose, Calif. 95134; 408-943-4861; fax, 408-943-2118.

International Workshop on VLSI Process and Device Modeling—VPAD (ED); May 14–15; New Public Hall, Nara, Japan; Masao Fukuma, Microelectronics Research Laboratories, NEC Corp., 1120, Shimokuzawa, Sagamihara, Kanagawa 229, Japan; (81+42) 771 0798; fax, (81+42) 771 0886.

International Symposium on Power Semiconductor Devices and ICs (ED); May 17–19; Hyatt Regency Monterey Hotel, Monterey, Calif.; M. Ayman Shibib, AT&T Bell Laboratories, Box 13566, Reading, Pa. 19612-3566; 215-939-6576; fax, 215-939-6795.

VLSI Technology Symposium (ED); May 17–19; Kyoto Grand Hotel, Kyoto, Japan; James T. Clemens, AT&T Bell Laboratories, 600 Mountain Ave., Murray Hill, N.J. 07974; 908-582-2800; fax, 908-582-2793.

Instrumentation and Measurement Technology Conference (IM); May 18–20; Hyatt Regency Hotel, Irvine, Calif.; Robert Myers, 3685 Motor Ave., Suite 240, Los Angeles, Calif. 90034; 310-287-1463; fax, 310 287-1851.

University/Government/Industry Microelectronics Symposium (ED); May 18–20; North Carolina State University, Raleigh; Jeffrey A. Coriale, North Carolina State University, Box 7920, Centennial Campus, Raleigh, N.C. 27695; 919-515-5053; fax, 919-515-5055.

23rd International Symposium on Multiple Valued Logic (C); May 24–27; Hyatt Regency Hotel, Sacramento, Calif.; K.W. Current, ECE Department, University of California, Davis, Calif. 95616; 916-752-0583; fax, 916-752-8428.

(Continued on p. 18H)

Calendar

(Continued from p. 18F)

Canadian Workshop on Information Theory (IT, Region 7); May 30–June 2; Le Riviera Conference Centre, Rockland, Ont.; T. Aaron Gulliver, Department of Systems and Computer Engineering, Carleton University, Ottawa, Ont., Canada K1S 5B6; 613-788-5734; fax, 613-788-5727.

JUNE

International Symposium on Electron, Ion and Photon Beams (ED); June 1–4; Sheraton Harbor Island, San Diego, Calif.; Fritz J. Hohn, IBM Research Division, Thomas J. Watson Research Center, Box 218, Yorktown Heights, N.Y. 10598; 914-945-1608; fax, 914-945-4121.

Conference on Insulating Films on Semiconductors—Infos '93 (ED); June 2–5; Delft University of Technology, the Netherlands; C.H. Klein, Conference Office Infos '93, DIMES, Delft University of Technology, Box 5053, 2600 GB Delft, The Netherlands; (31+15) 783 868; fax, (31+15) 622 163.

International Solid-State Sensors and Actuators Conference (ED); June 7–10; Pacific Convention Plaza, Yokohama, Japan; K. Takahashi, Department of Physical Electronics, Tokyo Institute of Technology, Ohokayama Meguro-Ku, Tokyo, Japan; fax, (81+33) 748 3135.

12th International Conference on Consumer Electronics (CE); June 8–10; Westin Hotel O'Hare, Rosemont, Ill.; Diane D. Williams, Conference Coordinator, 67 Raspberry Patch Dr., Rochester, N.Y. 14612-2868; 716-392-3862.

International Workshop on Charge-Coupled Devices and Advanced Image Sensors (ED); June 9–11; University of Waterloo, Ontario; Savaas Chamberlain, University of Waterloo, Electronic Computer Engineering Department, Waterloo, Ont., Canada N2L 3G1; 519-888-4598; fax, 519-746-6321.

Microwave and Millimeter Wave Monolithic Circuits Symposium (ED); June 14–15; Marriott Hotel, Atlanta, Ga.; Charles Huang, LRW Associates, 1218 Balfour Dr., Arnold, Md. 21012; 301-647-1591; fax, 301-647-5136.

National Telesystems Conference—NTC 1993 (AES et al.); June 16–17; Georgia World Congress Center, Atlanta; Eric N. Barnhart, Communications Laboratory, Georgia Tech Research Institute, Atlanta, Ga. 30332-0800; 404-894-8248.

Device Research Conference (ED); June 21–23; University of California at Santa Barbara; Thomas N. Jackson, Thomas J. Watson Research Center, Box 218, MS 30-156, Yorktown Heights, N.Y. 10598; 914-945-1947; fax, 914-945-3688.

Pulsed Power Conference (ED); June 21–24; Hyatt Regency Hotel, Albuquerque, N.M.; Janet Scowle, Sandia National Laboratory, Department 1240, Albuquerque, N.M. 87185; 505-845-7000; fax, 505-845-7003.

14th International Conference on Applications and Theory of Petri Nets (C); June 21–25; Bismarck Hotel, Chicago; T. Murata or S. Shatz, EECS Department, University of Illinois at Chicago, Box 4348, Chicago, Ill. 60680; 312-996-5488.

JULY

International Vacuum Microelectronics Conference (ED); July 12–15; Hotel Viking, Newport, R.I.; Charles A. Spindt, SRI, 333 Ravenswood Ave., Menlo Park, Calif. 94025; 415-859-2993; fax, 415-859-3090.

30th Annual IEEE Nuclear and Space Radiation Effects Conference (NPS); July 19–23; Snowbird Ski and Summer Resort, Snowbird, Utah; James R. Schwank, Sandia National Laboratories, Department 1332, Box 5800, Albuquerque, N.M. 87185; 505-844-8376.

AUGUST

Intersociety Energy Conversion Engineering Conference (ED); Aug. 8–13; Hyatt Regency Hotel, Atlanta, Ga.; Diane Ruddy, American Chemical Society, 1155 16th St., N.W., Washington, D.C. 20036; 202-872-4600.

International Conference on the Applications of Diamond Films and Related Materials (ED); Aug. 25–27; Sonic City Hall, Omiya Saitama, Japan; ADC '93 Secretariat, International Communications Inc., Kasho Building 2-14-9 Nihombashi, Chno-ku, Tokyo 103, Japan; fax, (81+03) 3273 2445.

International Conference on Solid-State Devices and Materials (ED); Aug. 29–Sept. 1; Nippon Convention Center, Chiba City, Japan; SSDM Secretariat, c/o Business Center for Academic Societies Japan, Honkomagome 5-16-9, Bunkyo-ku, Tokyo 113, Japan; (81+3) 5814 5800; fax, (81+3) 5814 5823.


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Circle No. 16

How Many Ca
Your Cake The Last
About Buy

EEs' tools & toys

(Continued from p. 11)

COMMUNICATIONS

Evaluating internet performance

A problem in testing data communications networks today is more often evaluating how well network segments work together through bridges and routers than how well they work on their own. Such testing involves the measurement of internetworking metrics like packet loss percentage, throughput, back-to-back capacity, and latency.

A new 20-page booklet from Wandel & Goltermann Inc., "Internetworking & Dual Simultaneous Analysis," discusses these issues. Dual simultaneous analysis involves looking at traffic on two interconnected network segments simultaneously in real time—observing and measuring the movement of frames from one segment to the other. Using W&G's DA-30 Internetworking Analyzer as a reference point, it reviews the evolution of data networks and the tools for testing them, presents three short case histories illustrating the value of dual simultaneous analysis, and gives details on the internetworking metrics emerging from the Benchmarking Methodologies Working Group of the Internet Engineering Task Force.

The booklet is available free of charge. *Contact: Wandel & Goltermann Inc., 2200 Gateway Centre Blvd., Morrisville, N.C. 27560-9228; 800-277-7404; or* **circle 107.**

Help with NetWare applications

Developers of data communications software applications that run under Novell Inc.'s NetWare have a good thing coming, or rather two good things. Novell is introducing a pair of software development kits (SDKs) for NetWare v4.0.

The NetWare Client SDK gives developers just one interface for writing DOS, Windows, and OS/2 applications in the NetWare 2.x, 3.x, and v4.0 environments. Because the kit provides a single interface, applications are easily ported from one desktop platform to another. Porting a DOS application to Windows is as simple as recompiling it for the Windows environment. There is no need to rewrite the NetWare portion of the application or to change the NetWare calls.

As currently offered, the NetWare Client SDK supports the Microsoft and Borland C compilers. Other compilers will be added in the future. The kit replaces four Novell older products: the NetWare C Interface for DOS, the NetWare OS/2 Developer's Kit, the NetWare C Interface for Windows, and NetWare System Calls for DOS.

The second SDK is a toolkit for writing server-based applications called NetWare Loadable Modules (NLMs), which can directly access the new and enhanced services of NetWare v4.0. The NLM SDK is compatible with the Watcom v9.0 optimizing compiler.

The SDKs are available exclusively to members of the Professional Developers' Program. The Client and NLM SDKs are priced at US $295 and $395, respectively. *Contact: Novell Inc., 122 East 1700 South, Provo, Utah 84606-6194; 801-429-7000 or 800-453-1267; or* **circle 108.**

INSTRUMENTATION

A better soldering-iron tester

To help manufacturers make sure that a faulty soldering iron does not inadvertently damage electronic equipment, the ST2100 Soldering Iron Tester measures tip temperature, resistance to

ground, and voltage with respect to ground—all in just a few seconds. The tester, from Wahl Instruments Inc., features a 4-1/2–digit display that resolves temperature to 0.1° (F or C), voltage to 0.01 mV, and resistance to 0.01 Ω.

To use the ST2100, the iron tip is held against the instrument's rugged and replaceable sensor wire while a function switch is rotated to read temperature, resistance, ac plus dc voltage, and ac-only voltage. A warning light-emitting diode lamp goes on if the voltage is more than 2 mV or the resistance is above 2 Ω. A second LED lamp warns of spikes greater than 100 mV that last longer than 1 μs.

The ST2100 comes with a probe for checking out solder pots and wave soldering machines. It is available in two versions: Celsius and Fahrenheit. Each is priced at US $1400. *Contact: Wahl Instruments Inc., 5750 Hannum Ave., Culver City, Calif. 90231; 310-641-6931 or, toll-free in the United States, 800-421-2853; fax, 310-670-2840; or* **circle 104.**

EDUCATION

Technology courses in Europe

A series of courses designed to give practicing engineers either a broader perspective on a general area or deeper knowledge of a specific technology is being offered at various locations in Europe. Different subjects will be covered at each location, but all of the offerings have a strong communications content.

Among the many subjects covered are fiber optics technology, adaptive signal processing, RF and microwave circuit design, low-sidelobe antennas, and analog CMOS circuit design. Courses will be given in Garmisch Partenkirchen, Germany, in February; Madrid, Spain, in March; Cambridge, UK, in April and May; and Stockholm, Sweden, in June.

Copies of the catalog and detailed course descriptions are available at no charge. *Contact: CEI-Europe/Elsevier, Box 910, S-612 25 Finspong, Sweden; (46+122) 17570; fax, (46+122) 14347; or* **circle 105.**

CONSUMER

Three-channel stereo mixer

Aimed at multimedia applications, the model MX-33 stereo mixer from Antex Electronics mixes signals from three sources. The unit accepts stereo inputs from a CD ROM, a personal computer, and a video disk and puts out a composite signal. The output is delivered in two ways: as a fixed level for connection to a pre-amp/amplifier or a pair of powered speakers, and as a variable level

Antex Electronics

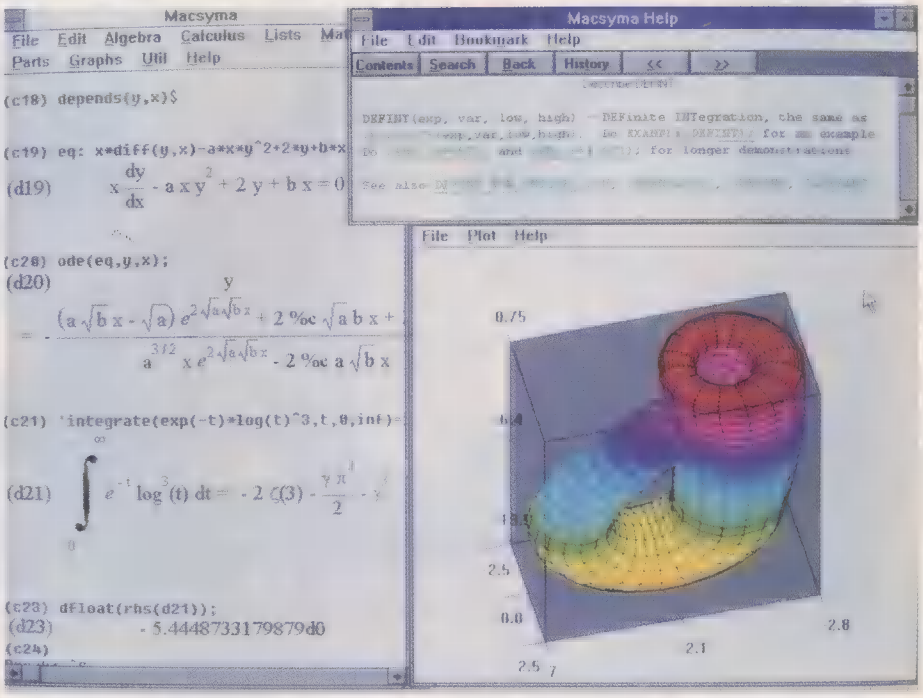
The MX-33 mixes stereo signals from CD ROMs, PCs, and video disks for PC-generated multimedia presentations of audio-visual material. Its front-panel headphone jacks deliver up to a watt of audio power.

for driving a pair of headphones.

The inputs and the line level output are connected through RCA jacks on the rear of the mixer. The headphone outputs, which can deliver up to 1 W, are on the front panel.

The MX-33 is priced at US $185 and is available from stock. Quantity discounts are available. *Contact: Antex Electronics, 16100 S. Figueroa St., Gardena, Calif. 90248; 310-532-3092; fax, 310-532-8509; or* **circle 106.**

COORDINATOR: Michael J. Riezenman
CONSULTANT: Paul A.T. Wolfgang, Boeing Defense & Space Group



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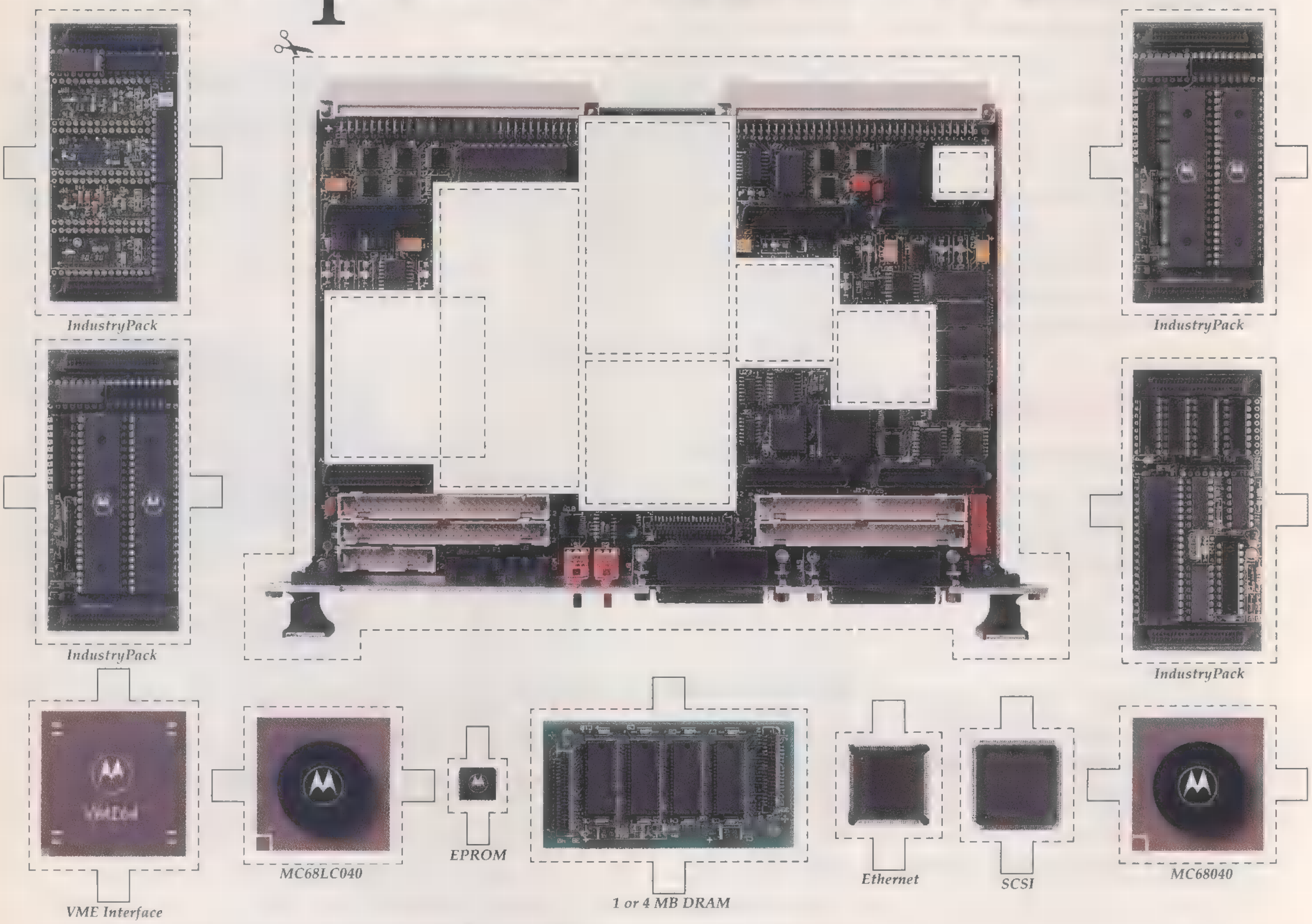

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Circle No. 13

Spectral lines

DECEMBER 1992 Volume 29 Number 12

Conversion: whose job?

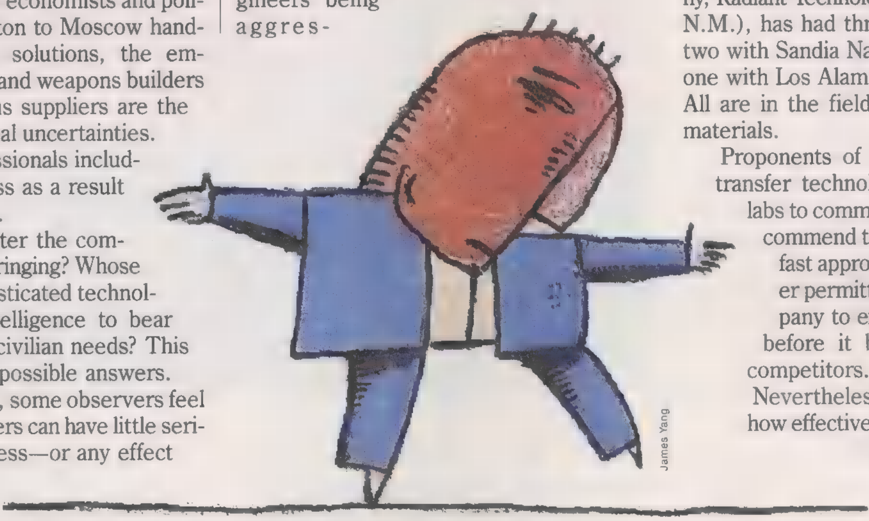
Walk the corridors of nearly any military contractor, and you'll sense concerns about the future.

While economists and politicians from Washington to Moscow handwring and postulate solutions, the employees of aerospace and weapons builders and of their numerous suppliers are the ones who face personal uncertainties. Many of them, professionals included, are already jobless as a result of military phaseouts.

But what comes after the commiserating and handwringing? Whose job is it to bring sophisticated technology and systems intelligence to bear upon commercial or civilian needs? This special issue weighs possible answers.

On the gloomy side, some observers feel that employed engineers can have little serious input to the process—or any effect on its outcome. For example, when the National Science Foundation (NSF) funded a study and workshop on U. S. engineers and economic conversion in July 1991, the results were disillusioning. While the study participants agreed that engineers will be the ones who undertake actual conversion efforts, their participation in policy-making or higher-level debate about conversion is minimal or nonexistent. The study group attributed this to traditional roles of engineers in private employment, where they have little say in what they work on. Company managers choose the problems, the group concluded. (Surely others disagree, at least to some extent. Where engineers are the managers, this would not be true, for example.)

The NSF study group also observed that engineers usually keep such a low profile on their personal values that they are not brought to bear in the area of how technology affects society, or societal problems. One might easily be led to conclude that government and industry leaders have given up on engineers being aggressive or effective in conversion policy-making.



James Yang

However, the group postulated some mechanisms to get engineers more involved [p. 26]. But can such mechanisms be put into place and will they work? The jury is still out.

Meanwhile, who is leading the charge to convert? In the United States, hopes are pinned in part on the transfer of technology know-how to nonmilitary industries from Government-owned or -operated laboratories [p. 53]. The Federal Technology Transfer Act (1986) and the National Competitiveness Transfer Act (1989) enabled cooperative R&D agreements between national laboratories and private organizations. Some agreements permit companies access to critical technologies, while others provide expertise in support areas like reliability and testing.

The Department of Energy programs that take advantage of these agreements are viewed by some as a bellwether. A number of them are under way in areas of materials and processes for semiconductor device fabrication. For example, one small company, Radiant Technologies Inc. (Albuquerque, N.M.), has had three projects accepted—two with Sandia National Laboratories and one with Los Alamos National Laboratory. All are in the field of perovskite ceramic materials.

Proponents of these joint projects to transfer technology from Government labs to commercial enterprises like to commend the minimal bureaucracy, fast approval, and a five-year buffer permitted the commercial company to exploit any development before it becomes accessible to competitors.

Nevertheless, it remains to be seen how effective these transfer programs will be when they are measured against the total problem. Furthermore, they are just one of an arsenal of conversion methods.

More often than not, companies are on their own in developing conversion strategies. They include transferring dual-use technology to commercial products, acquiring nonmilitary companies, and engaging in joint ventures with commercial organizations.

Irrespective of the conversion tack taken by their company, however, engineers must be alert to possible needs to realign their own career goals and skills, and maybe even relocate. In the end, the individual engineer must largely go it alone.

As an important part of this special issue, the staff has ferreted out some of the conversion successes of both companies and individuals. Let's hope they will serve as models for others.

Donald Christiansen

CONVERSION

The end of the Cold War has brought the expected cuts in military spending—and jolting upheavals to engineers and their companies. At military/industrial establishments around the world, budgets/sales sag. Engineers who have devoted their careers to high military technology stand jobless before employers having little interest in the traditions of the defense industry.

Few companies and engineers under threat can avoid conversion to civilian products. But the old ways conflict with the fast-moving commercial world and its alien engineering and business practices. Success stories can be found, all the same. The secret, it seems, lies in recognizing the differences between military and civilian engineering and either zeroing in on what defense technology has to offer the peaceful society—or acquiring skills that are new but related to earlier ones.

A group of university researchers begins this special issue by telling how it perceives engineers caught in military downsizing and what they must do to have some impact on their own destiny [below].

Engineers who have successfully converted tell how they did it—and one who is still job hunting reveals his frustrations [p. 29]. Companies large and small tell of diverse but successful conversion strategies [p. 37]. A company whose military technology had clear civilian potential found a partner with mass-manufacturing and marketing know-how, for example. Another lucked into a highly salable communication technique—and quickly moved to market it.

Conversion and the defense engineer

Like it or not, engineers ought to get involved in forging links between technology's capabilities and society's needs

Economic conversion—defined here as the shift of significant monetary and human resources from military to civilian applications of technology—hinges on engineering expertise. Yet engineers are not leaders in the U.S. conversion effort, nor even probable participants in the national discussion needed to set its directions and goals. That said, strategies do exist for engaging the members of the profession in conversion efforts.

After all, engineers are the link between society's needs and technology's capabilities. Technology is central to any type of economic conversion, being the physical means of change. It defines what products and services are possible, and also gives tangible form to society's values, which inevitably influence its direction. Very different social and economic priorities are embodied in the search for a more efficient automobile, a better bicycle, a transit system among major cities, or a fleet of faster Concordes.

Society's best chance of improving the human lot (and the planet's future) requires an open public debate on what values might be best in the future. Economic conversion, in the largest sense, has the potential to create a different integration of civilian and military production. Engineers will contribute their know-how to the new scheme of things once it is in force, and it is essential that they also contribute their knowledge beforehand to the debate about conversion.

The effect of the change on engineers can be stated very simply: as defense spending winds down, defense engineers will find work in fewer defense positions. Job searches are likely to be long, arduous, and less successful in some specialties (like aerospace) and for some categories (for example, engineers who are older, lack degrees, do technically very narrow work, and do work requiring a security clearance).

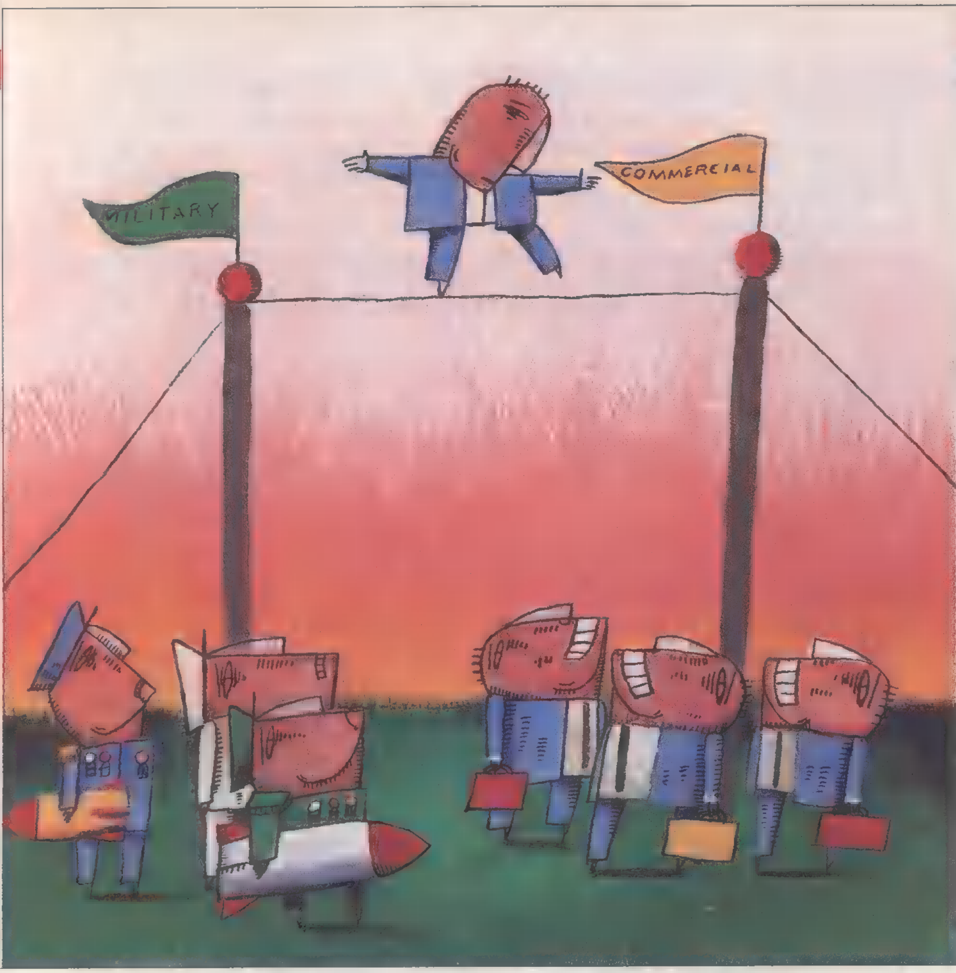
Engineers will also feel effects in other areas—pay, the marketability of their skills, and job satisfaction; personal values and political orientation; and as members of professional societies.

Salary levels are somewhat higher for defense than for nondefense engineers due, in part, to differences in age, education, and length of employment. Even so, the U.S. Office of Technology Assessment reported that defense industry outplacement data up until 1990 show no decline in salary for those moving into civilian employment. However, this may no longer apply in the current recession or amid the widespread displacement of engineers that conversion may bring in the short run.

Just how transferable engineering skills are from the military to the civilian sector is debatable. Performance in combat situations, not cost, is the prime consideration in military work, whereas civilian products evolve within severe cost constraints. Integrating these constraints in engineering design may require both a culture shift and retraining, as well as a reorientation of an engineer's technical knowledge.

Satisfying work for engineers is technical, well-defined, and challenging. Like other people, they appreciate good pay and benefits. Of less concern is the framework of values surrounding their efforts. Many defense engineers take pride, for example, in the fact that their efforts promote national security. That feeling, though, probably counts for less toward their job satisfaction than do a practical, action orientation and an interest in technical problem solving.

Martha W. Gilliland, Patricia MacCorquodale, and Jeffrey P. Kash University of Arizona
Andrew Jameton University of Nebraska Medical Center



Governments both local and national can help the conversion effort, and many are [p. 46]. U.S. Department of Energy laboratories have taken their new mission seriously: to transfer their defense-based technology to commercial industry [p. 53].

As for those defense engineers who want to reorient their skills toward civilian jobs, they should establish clear goals before joining retraining programs and peer support groups [p. 58].

Finally, eight people well-versed in the issue's pros and cons offer their views on conversion [p. 62]. One holds that it is not the answer for every company and warns against loss of military technology edge. Another reminds engineers that they are responsible for their own careers and must adapt to changing environments.

—Alfred Rosenblatt, Managing Editor, and George F. Watson, Senior Editor

If engineering jobs outside the defense sector are less technical and less well paid, job satisfaction could decline. It may be possible to convince engineers that their new line of work is socially valuable because, for example, it may increase economic competitiveness, protect the environment, or enhance energy security. But if the work is not technically challenging, discontent is likely. Landfill design, for example, is simply not as technical as missile design.

Historically, the technical workforce has had little say in what it does. Company managers choose the problems, and under current corporate structures, engineers rarely get involved in policy-making. At the societal level, participation may be discouraged if managers view employees' political activism negatively. Notwithstanding, the behavioral patterns, values, and cultural norms held by engineers will affect the role they play in economic conversion as well as the directions they might propose.

Engineers' personal values or beliefs on what is just have not been subject to much research. But if they value conversion and believe it just, they will support the process despite some negative consequences.

Many in the profession have a deeply rooted optimism about the effect on society of what they do, whether or not it is defense oriented. Their time is spent on furthering technology, often at the expense of personal or social interaction in the community. Their focus is often on things, not on society's role in progress or on how to define progress. Thus, involving engineers and society in conversion requires building bridges of values and meanings between the seemingly utopian goals of economic conversion and the present realities in the engineers' workplace. This will not be easy.

Engineers tend to belong to conservative organizations and to avoid political issues. They prefer to be challenged by solvable, discrete problems. They find unappealing the compromises associated with social problems and the open-ended nature of public policy issues. Engineers uninterested in social change may oppose conversion simply because it represents change. These same attitudes may discourage them from participating in a political debate regarding conversion's goals. Persuading them to participate may require appealing to them from an apolitical standpoint.

APOLITICAL OUTLOOK. For example, engineers may be motivated to work on civilian products through discussions with end users that would serve to connect them to the people they would be designing for. Appeals to achieve economic competitiveness and for dealing with environmental issues could lead to a variety of conversion strategies and potential products.

Apolitical appeals could also include cost reduction, efficiency, and superior or simpler technologies. In the early 1980s, for example, a United Auto Workers union local and the state of California's Department of Commerce worked with McDonnell Douglas Corp. in its Long Beach plant to produce mass transit vehicles and commuter aircraft.

While membership in political organizations that might influence their value systems is rare, many engineers do belong to professional societies. These bodies have not gone in much, if at all, for debates about values or societal issues. Rather, in tune with their members' tendencies, they have focused on technology, helped define the professional role of engineers, and served as a clearinghouse for technical and employment information.

For these reasons, engineers and their societies should not be expected to be dynamic advocates or groundbreakers in economic conversion. The conservatism and focus on discrete problems suggest support for the status quo. It seems most likely that engineers will tackle whatever problems companies or society set for them without passing judgment.

Incidentally, some evidence now suggests that professionals in the United States are beginning to redefine what they mean by success. They are looking for meaningful, in addition to well-paying, work. Whether this shift is occurring among engineers is unclear. But given their conservatism and resistance to change, engineers are not likely to lead the professional groups in a redefi-

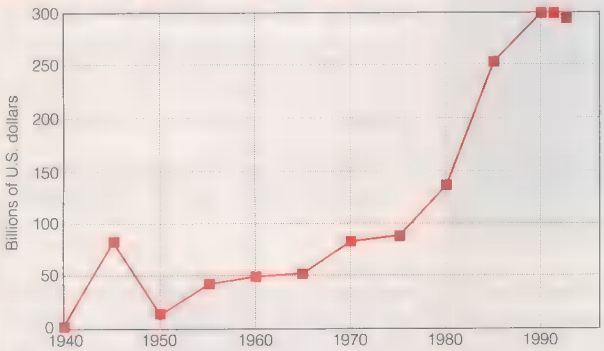
nition of the nature of work.

All this notwithstanding, engineers could be won over through a personal connection to the conversion process and to concrete activities. Eliciting their support is a task with at least four dimensions: pay, participation, professional self-expression, and professional ethics.

First, engineers, like other workers, enjoy the material rewards of a job. Many view defense work as attractive because it usually pays better, has more prestige, and is more interesting than civilian work. Equally satisfying jobs in the commercial sector would have to have comparable salaries, prestige, and technical challenge.

Second, interest is awakened by joining in the debate about conversion—on the job, in the community, and at state and national levels. Involving engineers in management decisions about new directions for their company, for example, should generate creative ideas and foster a buy-in to the process.

U.S. defense expenditures, 1940–92*



Source: historical tables, 1992 U.S. budget.
*Figures for 1991 and 1992 are estimates.

Though U.S. defense expenditures are declining from their recent peak, the decline has still been minimal. Major cuts, and even stronger impact on engineering jobs, are yet to come.

Next, the opportunity for self-expression through applying one's skills is a key motivator. Engineers' technical prowess has been directed at defense-related technology. To gain their support for conversion, they must be given specific technical challenges in the civilian sector involving such projects, for example, as infrastructure improvement, environmental protection, and competitiveness in manufacturing.

Lastly, engineering codes of ethics can be an important avenue to individual values. For example, most of the codes begin with a statement like "engineers must be dedicated to the protection of the public health, safety, and welfare and recognize that their work has a direct and vital impact on the quality of life for all people." Clearly, conversion can be interpreted to encompass programs that do exactly that.

TAKING THE LEAD. Institutions that might persuade engineers to think hard about conversion policy are the Federal government, engineering societies, and industry. The Government's influence is greatest. It controls financial resources that can be used to support a conversion policy. Through its many agencies it disseminates information in support of conversion to all levels of society. It can legislate into existence incentives for business and individuals to support conversion. And it can divert its expenditures from defense to other areas.

The Federal government must take the initiative in conversion planning, to ensure any negative impact is less severe and less prolonged than it would be if industry was left to its own devices. Also, the consensus on the direction conversion should take—toward rebuilding of the nation's infrastructure or toward manufacturing or environmental technologies, or a mixture—is best developed at the Federal level.

The Federal government must also reorder the priorities of the national laboratories. Through the U.S. Department of Energy, these laboratories—including Argonne, Brookhaven, Lawrence Berkeley, Oak Ridge, Lawrence Livermore, Los Alamos, and Sandia—get $5 billion to $10 billion per year to conduct research on technologies with defense applications, including the design, development, and testing of nuclear weapons systems.

Immersed as they are in the defense engineering culture, the labs would serve as a model for private industry if they can shift a significant part of their efforts to civilian R&D. The labs, in fact, may be pivotal in demonstrating how defense engineers can become civilian engineers. The labs seem well aware of their role in this mission.

Something else the Federal government can do is to establish joint ventures among government labs, universities, and private companies. These could be pointed toward developing technology for solving problems in the public domain.

Retraining undoubtedly warrants Federal support. It is required to refocus the national laboratories and the personnel in joint ventures. University fellowships for engineers to update their skills is one approach.

And taxes? The Government can offer defense companies incentives such as investment tax credits. These could be directed at companies that implement innovative programs for the development of civilian technologies. Obviously, such incentives raise issues of government interference in the marketplace, but such issues can be resolved.

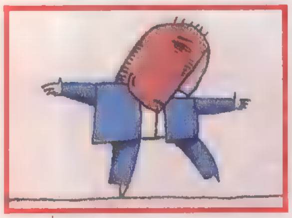
The professional societies are in an excellent position to guide their members. They have established communications networks, administrative support, and legitimacy in the eyes of political leaders and the public. To involve their members in the conversion debate, the societies can do a number of things. They are uniquely qualified to sponsor forums at local chapter and national meetings and to initiate discussions about how the engineering code of ethics applies to conversion. They can act as a clearinghouse for information about conversion. They can identify specific technical challenges associated with solving problems in the civilian sector, and they can design and implement retraining efforts. They can lobby Congress to pass bills on conversion that assist engineers.

In many ways, industry educates the working engineer. So when individual corporations try to identify which commercial products they will focus on, they must involve their engineers in those decisions. The profession's creativity and practical skills are essential to selecting feasible products, developing detailed plans for converting to consumer production, and determining mass-producibility. Industrywide job fairs, job banks, out-placement services, and retraining programs will ease the transition for displaced engineers and strengthen the morale of those who remain in charge of converting the firm.

ABOUT THE AUTHORS. The first three are from the University of Arizona. Martha Gilliland is dean of its graduate college and interim vice president for research. With a Ph.D. in environmental engineering, she has for 20 years taught and carried out research on water supply, pollution control, and hazardous waste clean-up technologies. Patricia MacCorquodale is associate professor of sociology and chair of the Women in Science and Engineering program. Her research for the past 12 years has focused on women's educational and work experiences in nontraditional fields, specifically mathematics, science, and law. Jeffrey P. Kash is a graduate student in the University of Arizona's department of political science. Andrew Jameton is from the University of Nebraska Medical Center, Omaha, where he is associate professor in the department of preventive and societal medicine and section head of humanities and law. He teaches and writes on ethical issues associated with health care.

This article and a book to be published shortly under the title Engineers and economic conversion: From the military to the marketplace *(Springer-Verlag) are a synthesis of ideas gathered at the University of Arizona, Tucson, from a two-year-long study and a three-day workshop sponsored there by the National Science Foundation's Program on Ethics and Values Studies in Science, Technology, and Society. The workshop was attended by about two dozen representatives of industry, academia, and professional societies, including the IEEE. The ideas and opinions are those of the authors and workshop participants and do not represent the National Science Foundation's positions or policies.* ◆

Engineers in profile



Some who switched from defense to other jobs followed diverse paths, including a few that proved dead ends

SLOCUM: riding the health care wave

Richard Slocum was never one to worry much about the future. With ■ BS in physics and ■ Ph.D. in nuclear physics from the Massachussetts Institute of Technology in Cambridge, he had impeccable engineering credentials, and for more than 30 years had his pick of interesting projects.

In the late '50s, he helped design radar and sonar systems at Raytheon Corp., in Wayland, Mass. In the '60s he joined the space race at the Aerospace Corp., working on nuclear power systems and on spacecraft systems. In the '70s, he moved to the Pentagon, to take part in projects involving naval systems and Arctic vehicles, and continued that work in California, at Air Logistics Corp.'s Sea Log Division in Pasadena.

But in the mid-'80s, the pickings grew slimmer. Sea Log's government contracts ran out, and as oil prices dropped, the promise faded from its effort to develop technologies for drilling for oil in the Arctic. In 1987, Slocum was told that while he was not being fired, the company had nothing for him to do, so it would be better if he left.

As jobs were still plentiful, Slocum made the stereotypical career move of the California electrical engineer—he crossed the street to Kodak-owned Datatape Inc., which built tape recorders for government and military customers. Slocum took over the company's Avionics Integrity Program, an Air Force reliability effort.

But in September of 1990, with Datatape in financial trouble, Slocum was laid off. Still not worried about the future, he seized the chance to do things he enjoyed. He had taught a physics class at Pasadena Community College since 1987; he added a few more classes. He sold insurance. He taught at local public schools as a substitute teacher. He began to work as an environmental consultant.

One thing he did not do for six months or so was look for a full-time job. "I loved doing all these things," Slocum told *Spectrum*. "It didn't bother me that I wasn't getting ■ regular paycheck."

Then reality stepped in. Of Slocum's five children, three were still teenagers, with one in college and another making college plans. He had no savings. His health insurance payments had risen to US $700 a month, the mortgage on his large Pasadena home was substantial, and the credit card bills were starting to climb.

Slocum began trying to figure out his future, and after contacting about 100 companies, he saw it would not be in defense. The environmental field was hot, though, and he thought he would "just move into it full-time, since I was the great physicist with so much experience." However, while the field does build on basic science and technology, he found it had many important ins and outs.

All was not lost. At least one small piece of his defense expertise was transferrable to environmental work—risk analysis. At Raytheon, Slocum had done analyses of new systems based on probability projections of what the enemy would do. At Aerospace, as a systems engineer, he was concerned about reliability. Even at Datatape, his job involved statistics and reliability analysis.

He joined an environmental engineering program at the University of California at Los Angeles and took classes on risk analysis and other subjects. He was able to step up his environmental consulting en route to a full-time job. In the meantime, Kaiser Permanente in Pasadena advertised in the newspaper for a biomathematical statistician, and Slocum applied. (Kaiser is the nation's largest health care organization.)

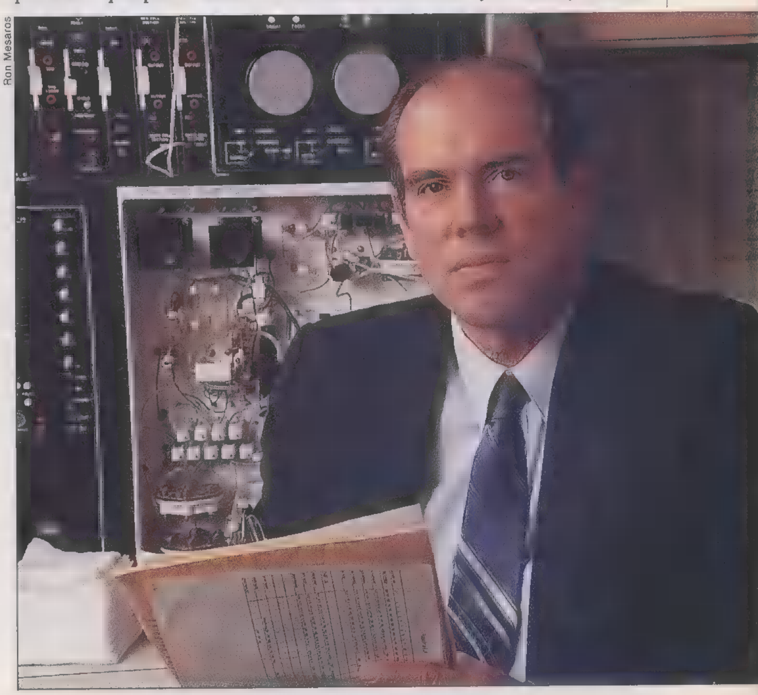
"I had some trouble convincing people I was right for the job," Slocum said. "My [only related] formal training was in nuclear physics, applied mathematics, and environmentally related health effects." What he did have was experience in simulation of complex systems, and Kaiser was willing to take a chance that those skills could be applied to perhaps the most complex system of all, the human body. Slocum was hired in April 1992, more than a year and a half since his layoff and after one year of serious job-hunting.

Today, Slocum analyzes the risk/benefit balance of applying different health care technologies, such as laser tools, radiation treatments, and operating procedures, to various forms of cancer and other diseases. He trained himself to use computer systems—his previous risk analyses were done with slide rules and calculators. He is reading medical journals and talking to physicians.

His goals at work are much nearer term, and the results more immediate and implications larger than anything he did in defense. "I prefer the faster pace," he said, but, a little wistfully, "I really loved nuclear engineering."

The biggest difference from defense, Slocum said, is the end product—people's health versus hardware, and "you can't just yank

Ron Mesaros



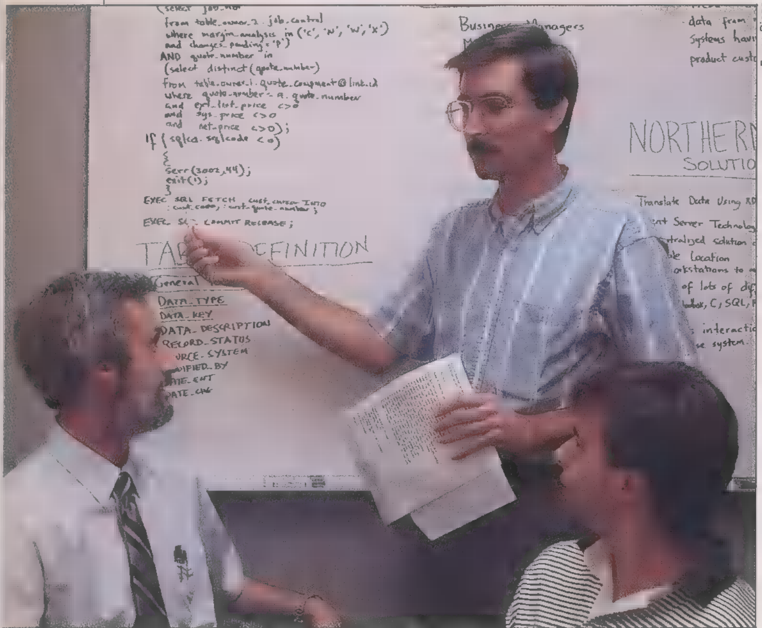
Tekla S. Perry Senior Editor

people around, you have to be concerned for the patient.''

For Slocum, age 58, retirement is not in the foreseeable future—he calculates his total pensions, aside from Social Security, at $90 a month. So he expects his new health care career to last.

What has he learned? ''Play on, using the talents developed through education, employment, and life in general, and apply them to areas that need them now—a struggling health care system, deteriorating environment, famines. . .the problems are many.''

BEGGS: beefing up software skills



Bruce Rinne

The end of Barry Beggs's defense career came with little warning. A few days before Christmas 1990, employees of General Dynamics Corp., in Fort Worth, Texas, received a memo that the program for the Navy A-12 advanced attack aircraft might be canceled, and if it were, there would be some layoffs. On Jan. 7, 1991, employees were told of an impending announcement from Washington, D.C., but by 4:30 p.m. no word had come, and everyone went home. When Beggs arrived at work the next day, he was told to clean out his desk and leave. Altogether, 3500 employees were laid off. ''I was numb,'' he recalled. ''And suddenly I was standing in line waiting to hand in my badge and thinking this is for real, I have to look for another job.''

By that time, Beggs had been designing systems for F-14, F-16, and A-12 fighter aircraft for five years, ever since receiving his BS and MS from California State University in Northridge. He had worked first at Grumman Corp. in Point Mugu, Calif., and then at General Dynamics.

Now, the 31-year-old electrical engineer is employed by a contracting company on a C-language programming project for Northern Telecom Inc., in Research Triangle Park, N.C. Six months ago, he was designing digital signal-processing algorithms and software for Bell Northern Research, a subsidiary of Northern Telecom and also located in Research Triangle Park. Six months from now, he doesn't know what he'll be doing. What he does know is that if his skills are not completely current, he will not have a job.

Switching from Navy projects to commercial communications projects took more than a move to North Carolina; Beggs had to reevaluate his talents and make some major lifestyle decisions.

When the layoffs hit, he had no résumé prepared and no idea of what other jobs Fort Worth offered. He soon found the local employment picture was bleak: companies were receiving over 1000 résumés for each position advertised, and engineers laid off a year previously were still hunting. Beggs sent out 40 or 50 résumés, revising them as his systems engineering skills proved unsalable and as he struggled to identify marketable talents. He began wondering how low a salary he would be willing to take, just to get a job—US $25 000, $20 000? (about half his General Dynamics' wages). With 20 rejection letters in hand, he qualified for some government retraining money, and used it to take a refresher programming class in C. He also highlighted some volunteer work on digital-signal processing hardware, helping students at the University of Texas, Arlington, put a visual identification system into a flying robot.

Seven months after the layoff, Beggs became an assembly language programmer for an entrepreneurial venture in Fort Worth at two-thirds of his previous pay; but it had limited appeal for him.

Finally, a job offer came from a Durham, N.C., contracting firm intrigued by his digital signal-processing experience. There are about 40 employees, and the focus is on software projects in information systems and on tools for computer-aided software engineering.

Beggs is not sure how the company got his name—he's just grateful it found him. All the same, it was no easy matter for him to pull up stakes and move to North Carolina in October 1991. Though single, Beggs was very active in the Fort Worth community and had a girlfriend he was loath to leave behind.

These days, Beggs likes what he does, likes where he is living, and is taking home a slightly higher salary than he did at General Dynamics. But he does not feel as well off.

Of keenest concern is security. ''The stability of what I'm doing is not good,'' he said. His company will employ him only as long as it has work for him. As a precaution, Beggs talks to people, reads professional journals, and browses through computer bulletin boards to find out what technologies seem ''hot''; then he spends at least 5 hours at home a week doing engineering projects of his own in the hot areas. Among those he is currently watching are C++ programming and client/server software for database systems.

The work Beggs is doing now differs sharply from his defense experience. The projects are smaller, shorter-lived, and less well documented. He interacts less with the customer, and budgets are tighter. ''If I were with a defense contractor now,'' Beggs said, ''I'd start doing some outside training, and look at what it would take if my number is pulled.''

WERTHEN: an entrepreneurial gamble

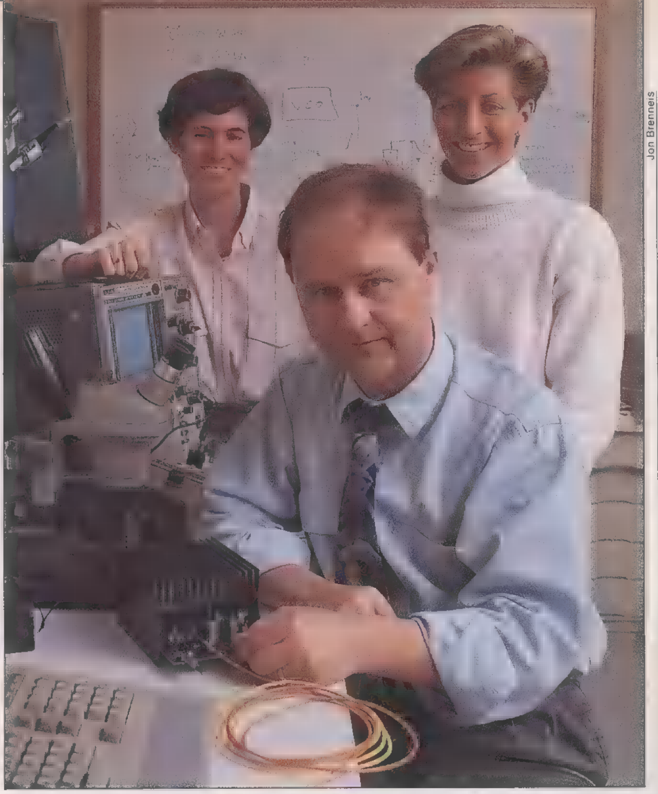
Varian Associates decided to stop doing Government research in solar cells in 1990, whereupon Jan Werthen, its solar cell R&D manager, put together a deal to buy the business. He had the backing of Kopin Co., a Massachusetts company already active in the field. So along with five other researchers and most of their equipment, he helped Kopin set up VS Corp. in San Jose, Calif.

But Werthen and Kopin had different goals. Kopin expected Werthen to continue doing what he had done at Varian in Palo Alto—competing for contracts from the departments of Defense and Energy (DOD and DOE), the National Renewable Energy Laboratory, and other Government groups that fund solar cell development.

After nearly a decade, however, Werthen was through with working for the Government. In his days as a doctoral student, he had done research for DOE and DOD. (He has a master's in engineering physics from Chalmers Institute of Technology in Sweden, where he was born, and a master's and Ph.D. from Stanford University in California.) Postdoctoral work at Xerox Corp.'s Palo Alto Research Center had him looking into laser diodes for the Air Force.

Then he joined Varian, where he worked on improved coatings for gallium arsenide wafers, and designed a metallorganic chemical vapor deposition system, again for the Government. Promoted after two years, he became program manager for nearly a score of engineers employed on various Government contracts. Meanwhile, he stopped doing hands-on research himself and, he said, turned into ''a proposal writer, a report writer, and a presentation giver.''

By 1991, defense money was obviously shrinking, and the engineer in him was tired of completing projects with nothing to show



for his efforts but a few reports and sample devices. He wanted to make a real product. And he had one in mind.

At Varian, one device developed by his group was a photovoltaic power converter—a GaAs chip that receives light through an optical-fiber cable and converts it to as much as 1 W of electric power. The efficiency is higher than for a standard solar cell because the incoming light is monochromatic. One significant commercial use is in powering sensors where electromagnetic and radio frequency interference or isolation are issues; an example is monitoring high-voltage systems in an electric utility substation.

The prospect was promising. Werthen decided to take his technology to another company—his own. He left VS and in November 1991 set up Photonic Power Systems Inc. in his Cupertino garage. Two members of his old group joined him in February and, after reaching an amicable agreement with VS, they bought some of VS's equipment and moved to rented office space in Palo Alto.

Photonic Power manufactures on underutilized equipment it rents at Varian. In March, its first products bowed—2-, 6-, and 12-V GaAs power converters. April saw the arrival of an isolated-power and data system, in which a controller lets the sensor return data over optical-fiber cabling. Werthen expects 1992 sales to total US $175 000, and 1993 sales to pass $0.5 million.

To fund the venture, Werthen cashed in his retirement accounts and persuaded a few friends to invest. It was a risky move for a 41-year-old expecting his first child, but "you only get a chance like this once," he said. Today he is trying to raise enough capital to grow into a $100 million business, though he is meeting some unwillingness among financiers to believe a defense engineer can make a profit.

Differences between his current enterprise and his defense work are many. When he did Government research, he recalled, horizons were far away and the boundaries were wide, leaving a lot of freedom for exploration. "That is completely gone now," Werthen told *IEEE Spectrum*. "Now I have to stay focused." He talked wistfully about an idea he has for another type of power converter, but said he tries to not even think about it—for now, developing it to the point of filing for a patent is out of the question.

"So the freedom is gone; but the feeling I have when we ship a product and someone calls back and says, 'Hey, this is a great thing you've got, we want to order a hundred,' is like nothing else."

Costs have to be kept down and quality kept higher than before. Under a Government contract, an engineer might make one highly successful device, he observed, and "write a paper on it, even though it takes two years to reproduce," but "we would lose our shirts if we made a claim that every device doesn't live up to."

Also, whereas formerly he focused purely on technical challenges, these days, he has his hands on everything—from purchase orders, to product development, to packing completed units in styrofoam for shipping. "Sometimes I think my brain is going to explode because I'm thinking of all these things at once," he said. He has also learned about finance and law on the job, having no time for formal classes. "My financial situation is in the ditch, and I'm working twice as many hours," he told *Spectrum*, "but I'm a lot happier."

Werthen suggests that engineers now employed on defense contracts spend their evenings in school. "At a big company, if you put in a real eight hours, you don't need to stay any later, and you have more hours in the day," he said. He wishes he had used those extra hours to get an MBA, but any extra education would help. Said Werthen: "When companies find themselves with a surplus of engineers, you have to be multifaceted or end up on the street."

GILES: the perfect job

Three years ago, when C. Lee Giles decided to move from the defense megalopolis to the industrial world, few U.S. companies were investing in long-term basic research—his forte. But U.S. branches of Japanese companies were doing so, and at NEC Corp.'s new Research Institute in Princeton, N.J., the 45-year-old Giles found what he considers the perfect job.

Giles had once been in the commercial world, briefly. In the early 1970s, he had worked on systems for the optical inspection of automotive components at the Ford Motor Scientific Engineering Laboratories in Dearborn, Mich. Meantime, he studied for a master's degree in physics at the University of Michigan, in Ann Arbor. But, from 1980, when he received his Ph.D. at the University of Arizona, Tucson, until the NEC job, the bulk of his research was done for various branches of the Department of Defense (DOD).

"Defense agencies support most of the optical science research," Giles told *IEEE Spectrum*, "so if you want to do interesting work, they are who you turn to. The DOD was funding some of the most innovative research anywhere." And Giles wanted innovative research.

By 1985, his interests had tilted more toward neural networks. He left a post at the Naval Research Laboratory to move on to the Air Force Office of Scientific Research. As program manager, Giles developed a neural networks research program as well as reorganiz-

ing and strengthening the optical computing program. His own research got short shrift, though, and if he was ever to do it full-time, he knew he would have to leave.

In 1989, his new programs were firmly established, and Giles decided to look around, at defense research opportunities as well as positions in industry and academia. "With the Cold War ending, I knew that defense would be receiving less funds and playing a less important role in the economy," Giles said. So when he was offered several defense research jobs that suited his skills and interests, he turned them down, feeling their future was limited.

Fortuitously, NEC Corp. was in the throes of assembling a group of research scientists and engineers to start its first U.S.-based research organization. Its charter: to pursue lines of basic research that could lead to new ways of doing computing and communications. Giles joined the fledgling group, then numbering 10 researchers, as a senior research scientist. (The laboratory now has some 40 scientists and engineers with Ph.D.s, and is still expanding its research staff.) He is currently working on neural networks and optical computing.

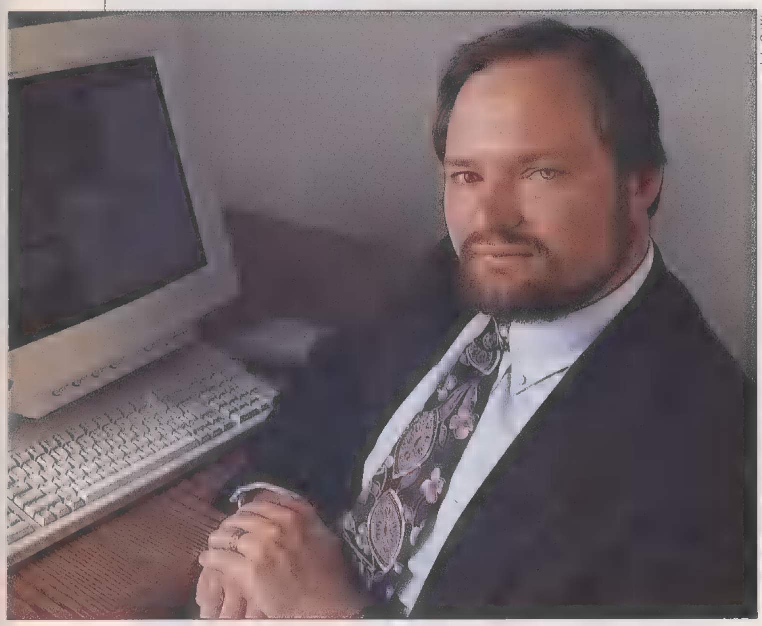
The attraction? Freedom and support. "I was given freedom to do what I wanted to do, and a healthy budget to do it," he said. And, perhaps not insignificantly, as Giles and his wife have started their family, a higher salary.

The freedom proved energizing. When Giles sees a new avenue of research related to computing, he pursues it. When he needs a new computer system, like a recent Silicon Graphics workstation, and he has funds in his budget, he can buy it. That would have been very difficult in most Government positions. He is also free to publish all the results of his NEC research wherever he sees fit.

The move from research funding back to research also means much less paperwork. Instead of the half a dozen or more lengthy briefings to various officials and agencies that Giles gave annually in his Air Force research office post, he writes a brief report every six months. That leaves him with more time for the research he loves. He has stayed in the same scientific and technical areas, though he goes on learning more about computing. The NEC work he finds equally as stimulating as his Government work.

In an era in which industry as well as Government is cutting back on funding for basic research, Giles is well aware just how unusual his position is. But, he told *Spectrum*, as the economy starts to rebound, he expects to see more "good opportunities for [defense] scientists and engineers who have documented their past accomplishments."

HELMER: no more blackout



L.L. Griffin

For Thomas Helmer, moving from defense to commercial engineering was like stepping out of a cave into bright sunshine—literally. At Hughes Aircraft Co., Denver, Colo., he lived amid thick windowless concrete walls. Now his office has a large window looking onto the Rocky Mountains' front range. But he is rarely at his desk. As a senior technical consultant for UGC Consulting in the Denver suburb of Englewood, he is often on the road. He works with gas and electrical utilities and local governments on developing distributed interactive databases that will help them track everything from power line voltages to construction permits.

And Helmer is loving it.

Helmer, 31, received his BS and MS degrees in computer science from the University of Southern California in Los Angeles. He started working for Hughes Aircraft Co. in Fullerton, Calif., in 1982, while still in school, moving to Hughes in Denver in 1988.

One project he can talk about involved the elements of a command and control system that was to be used by the North Atlantic Treaty Organization in Norway and Denmark. The basis was Norwegian minicomputer hardware. For the project, Helmer wrote a real-time debugger that would operate across a string of central processing units (CPUs); developed a system for processor-to-processor communications; and worked on a database that could take information from a variety of sensors in real time.

In 1989, Helmer and a handful of other computer engineers started a new Hughes division, going after nondefense governmental contracts as well as commercial business opportunities. But at Hughes Spatial Data Systems, Helmer worked only on proposals and stopped "getting the chance to build anything."

So this year, after a decade at Hughes, Helmer decided to jump to the commercial sector. "I didn't like working on proposals and not winning them," he told *IEEE Spectrum*. Moreover, a shrinking defense industry had already cramped his career. "I had been a fast tracker at Hughes," he said, "well compensated and rewarded" and, he once thought, en route to technical director of a US $400 million-plus program. But in 1991 Hughes froze raises and promotions for employees at his level, and his opportunities died.

He had no worry about finding commercial work because his background in computer software and distributed databases was in demand. He first considered Wall Street, and soon had two offers from investment firms in New York City. Then he was recruited by UGC in Denver. "It came down to [this:] did I want to work on the East Coast, or stay in Colorado? I love Colorado, the fishing, the skiing, golf, so I stayed."

At UGC, Helmer is a senior technical consultant. His work in Geographic Information Systems (GIS) and Automated Mapping and Facilities Management (AM/FM) is in a booming field. Most of UGC's more than 800 projects involve electric and gas utilities and local governments interested in analyzing their geographic data. There is little bureaucracy, and Helmer is pretty much his own boss.

One of Helmer's current clients is the City of Riverside, Calif., for which he is building a GIS running across a network of 30 Sun workstations and 60 personal computers. The GIS takes information essential to the electric power, water, and sewerage systems and integrates it with standard city records, such as tax assessments and building permits. Simply by pointing to a location on a map, a user can get a host of pertinent information.

The down side is much less of a technical challenge. "That would have bothered me five years ago," he told *Spectrum*, "but I'm more realistic now. You can't always work on the leading edge. Now I get my enjoyment from seeing things completed and showing people how to apply information technology to their problems."

At one time, Helmer had expected to work in the defense industry until retirement. Now he sees a much different life ahead. He expects his work to be increasingly lucrative, until he can cut back to occasional consulting in his mid- to late 40s. Then he will finish his Ph.D., teach at a small college, and ski a lot.

His advice to other defense engineers? Start networking: "A lot of us made the move [to the commercial world] before we had to—we may be in a position to help folks."

BABAIAN: Russian signs with U.S. company

Sun Microsystems Inc.

For Soviet scientists and engineers, the sole employer in recent history has been the Government. So when Boris Babaian graduated in computer science from the Moscow Physical-Technical Institute in 1957, he knew who would employ him—but not where and how.

He was to become known in technical circles as the Seymour Cray of the Soviet Union. But when he joined the Government's Institute of Precision Mechanics and Computer Technology in Moscow, he at first worked on algorithms for speeding up mathematical operations. In the late '50s, he was part of a team that developed one of the first Soviet real-time computers, the M-40. In the '60s, he moved to fault-tolerant systems. In the '70s, it was on to multiprocessor architectures for supercomputers Elbrus-1 and -2, which were used by other government organizations in both civilian and military applications.

In 1990, a team of some 200 researchers under the 58-year-old Babaian began designing the Elbrus-3, a 16-processor supercomputer. The Soviet Government was in turmoil, and at any moment funding could disappear and his group be disbanded. Concerned to keep them all together, he began talks with European, North American, and South Korean companies. He was looking for one to hire him and many of his researchers for commercial work. A lot of interest was forthcoming, he told *IEEE Spectrum*, but no firm offers.

Then in late 1990, at a meeting in Moscow for users of workstations based on Sun Microsystems Inc.'s Sparc microprocessor, Babaian met two executives from the Mountain View, Calif., company: chief technical officer Bill Joy, and director of the science office John Gage. Several discussions later, Babaian agreed that he and 50 of his people would conduct research in fine-grain parallel high-speed microprocessor architectures and corresponding compilers in affiliation with Sun Microsystems Laboratories Inc.

A second project began this summer with SunPro, Sun's software development unit, focusing on compiler software for existing Sparc workstations and involving 33 of his researchers. Meanwhile, other researchers at the Institute of Precision Mechanics work away under Babaian's direction at the Elbrus-3, expected to be complete in early 1994.

Babaian and his researchers, now organized as the Moscow Sparc Center, have had to acquire many new skills for the commercial world, mostly learning as they go. For instance, costs have to be estimated and controlled more tightly. Also, intensive classes in the English language have been set up (while SunPro counterparts in California are learning Russian).

His technical focus has changed little, Babaian told *Spectrum*, but he finds it possible to do more on equipment using better silicon technology. Deadline pressures, he said, exist in both his jobs, but with Sun's resources (providing workstations and other tools), "the possibility to do the work in time is better."

The hardware available to the Russians as Government employees is not as good and less reliable, Babaian observed. But, he told *Spectrum*, because "in our past work we had very unreliable hardware, we have had a lot of experience designing reliable systems using unreliable components. I think this experience will help us in our new situations."

The biggest surprise? That the U.S. engineers with whom he collaborates have the same personalities as engineers in his country. The biggest boon? That the commercial link with Sun lets him keep his researchers productive and together, so that eventually they may form the core of a Russian computer business.

As for the highly unpredictable future, "my only hope is that our joint work with Sun will continue for a long time and all our projects will be successful."

EASON: turning proposal writing into a career

It was a rude shock. Jean Eason had been a lead engineer on several avionics systems projects—for the F-16, for "next-generation" aircraft, and for the V-22 tilt-rotor helicopter, among others. But in June of 1989, when she logged on to her computer terminal at Bell Helicopter-Textron Inc., Fort Worth, Texas, her password did not work. She tried to log into a different system, and was also shut out.

This was her employer's way of telling her and other engineers that they were laid off. Eason, age 36, knew at once that finding a new job would not be easy.

But she thought she had an edge. She had tried but failed to find a nondefense job after 10 years at General Dynamics Corp. and before joining Bell. So during her four years at Bell, she had studied part-time for an MBA at Texas Christian University nearby. (She already had her BSEE from the University of Texas in Austin and her MSEE from Southern Methodist University in Dallas.) Eason received that MBA one month before her layoff.

However, in the dismal Fort Worth job market, the MBA was of little help. The best Eason could find after four months of looking was a position at a start-up company called Visual Data Systems Inc. in Plano, Texas, 90 km away. A group of former defense executives was trying to develop and market computer systems for simulation and training. Eason worked there for nine months, but the company was struggling, and pay checks erratic. She continued

Kevin Leigh

to search for a nondefense job. Then a headhunter helping her told her she was a hard sell. "I know you can do this stuff," he said, "but everybody gets scared off by your military experience."

So Eason reevaluated her skills. As a systems engineer, she had written engineering proposals and systems specifications as well as doing design definitions, systems analysis, and preliminary testing. At Bell Helicopter, she concluded, her job was 30 percent writing. At the urging of a fellow MBA graduate whose girlfriend had started a technical writing career, Eason put together a résumé featuring her writing skills. One year after her layoff, she handed the résumé out at a job fair, and in a few weeks had an assignment from an oil company: documenting the software for a very large internal computer system that handled revenue accounting.

That job lasted 18 months, at a salary somewhat less than her most recent defense position paid. Now Eason has decided to stay in the technical writing business, working out of her home, and finds she has to brush up on her marketing skills. Currently, she is putting together a networked computer system for a small business, developing custom PC applications; editing a psychology book; developing workbooks and training manuals for employment assistance courses dealing with job-hunting; and producing newsletters.

"The technical challenge doesn't compare at all [to defense work]," Eason said, "and I miss that part of it. But I love the lack of bureaucracy—there is not enough money in the world to pay me to go back to [defense] work conditions." She recalled without nostalgia accounting for her time in six-minute blocks and trying to justify bathroom breaks, bosses who took attendance at 8 a.m., and security hotlines that encouraged co-workers to call in if someone had a nicer car than they thought his or her salary should run to.

Today, Eason is making about 60 percent of her former defense salary, and she has no benefits. But, she said, at military companies engineers are a commodity, added and subtracted to staff programs with no thought being given to their needs. "Now," she said, "I'm treated like a professional, so I think I'm better off."

Eason believes that many former defense engineers on the job market are wearing blinders. "They have a mind set that says, 'This is what I do.' They don't see the realm of possibilities out there."

SMITH: two years and still looking

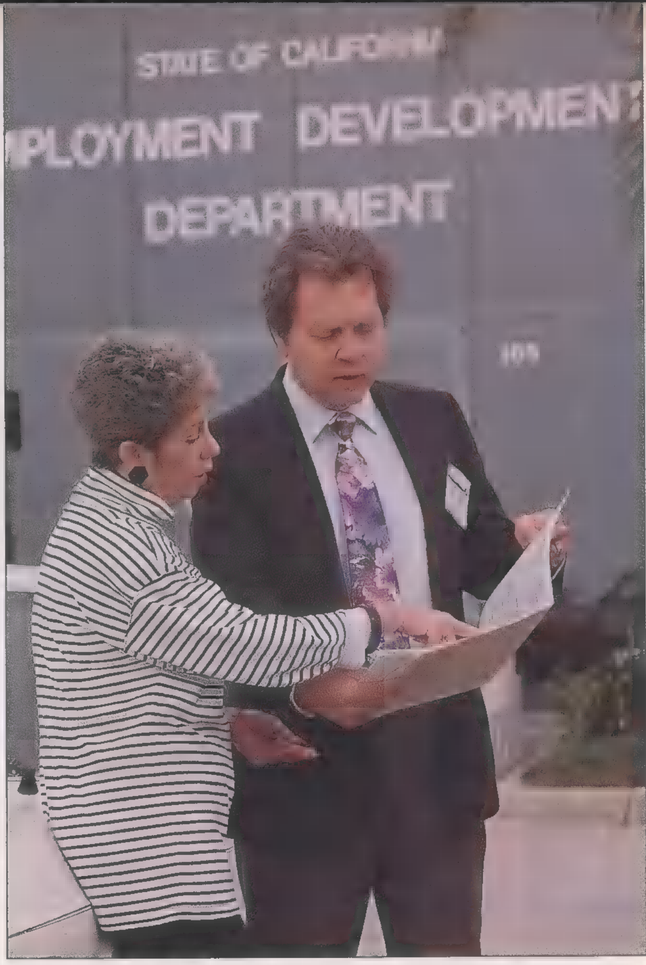
For the past two years job-hunting has been Thomas Smith's full-time job.

Smith, now 47, has worked in defense engineering for more than two decades. With a BS in physics from California State University in Northridge and an MS in systems engineering from West Coast University in Los Angeles, Smith decided on a career in contract engineering. It paid better and offered greater variety than a comparable staff position.

Under the auspices of several contract engineering firms, Smith worked for the Jet Propulsion Laboratory in Pasadena, for ATE Associates in Northridge, for Hughes Aircraft Co. in El Segundo and Canoga Park, for Northrop's Ventura Division in Thousand Oaks, and for several other California companies. Some of these positions lasted longer than many full-time jobs—he was at Hughes for more than eight years.

His background is in electronics, physics, and systems engineering, but his tasks along the way were mostly software oriented. He worked on software for the laser range finder subsystem of the AI robot vehicle; developed test programs and analyses for B-1 bomber systems; worked on a vibration control system for the Trident submarine; and wrote software for a laser-optical system to be used in antisatellite tracking, real-time guidance software for missiles for the Bradley fighting vehicle, and a graphical user interface for a laser weapons test system.

He said he typically received at least three calls a month offering new positions, so in June 1990 when he completed a project at Rocketdyne Division of Rockwell International Corp. in Santa Susana, Calif., "I went to my answering machine to pick up my next assignment," he told *IEEE Spectrum*, "but there were no calls."



Ron Mesaros

Since then, his phone has brought him only one job offer—an 11-week assignment doing inertial navigation system design and systems analysis at Litton Aero Products in Moorpark, Calif.

With his usual dedication, Smith set out to learn a skill entirely new to him—looking for work. It has become a more than full-time occupation. He would prefer a job in the commercial sector, but has been applying for defense jobs as well. He has contacted scores of companies in the Los Angeles area, within commuting distance of his home in Simi Valley, Calif. Pulling up stakes is out of the question—his wife is a 24-year employee of nearby Hughes Aircraft Co. in Canoga Park.

Smith's hope is to find a small commercial company that needs an engineer with a general problem-solving background; but such a position has yet to surface. He has been called in for only a few interviews, selected from as many as 300 other applicants, but he has been passed through to engineering for an interview only three times. His résumé rarely makes it past the personnel department because, he believes, "While I've been working in computer systems and languages, I'm not strictly a computer science person; and since I have only designed hardware as needed for interfacing, I'm not considered an electrical engineer; and since I haven't been working with materials, I'm not really a physicist."

When he makes the first cut, the second cut is often a test. "But having worked in five or six programming languages," he said, "when I'm not working on a real project, and am just asked to write a short program, I forget the syntax—should I use parentheses or brackets—and I fail."

He also has discovered that while his extensive experience in personal computer software is in demand, so is a knowledge of local-area networks, which he lacks. He has taken a self-study course in object-oriented languages, another hot area, and intends to continue self-study in such topics as remote sensing, control theory, computer-aided design, and digital filtering.

Smith is running his job search from his home and from the local employment development office, where a "job club" (called Opportunities for Professionals Employment Network, or OPEN) provides office space, telephones, and computer equipment. Each day,

he spends about three hours at the library, researching companies, another two hours on the phone, and about three more studying engineering topics that he thinks might be useful, like aspects of PC software design. He has attended seminars on how to find a job.

"People who are still working have this image that I'm surfing all day, whereas I'm spending a longer work day than I did when I had a job," Smith said. "Working would be a relief."

Smith's wife is supporting the family financially. To stave off feelings of defeat, Smith devotes some time to engineering projects. He is working on four patents, including one for a marine navigation system that he dreams of developing into a product and marketing through his own small company. "But without funding," he said, "that's a pipe dream." He also stays useful by working with local IEEE Sections to help other unemployed engineers.

The worst moments Smith has had during these two jobless years have been when people suggested to him that he should do something else. "No one would ever tell a businessman, 'Gee, try something else, be a physicist,'" he said. "So how can they tell an engineer to step out and open up a coffee shop?" Smith has no intention of getting out of engineering.

ZDASIUK: a prophet in his own lab

The research group at Varian Associates had been working under government contract on gallium arsenide and other III-V semiconductors, and their director, George Zdasiuk, wanted to refocus them on a commercial area. Medical device research looked right for their skills. But his then boss told him the switch "would be too disruptive."

But Zdasiuk wondered why. It was 1990. The Palo Alto, Calif., company had decided to get out of III-V semiconductors. Some research engineers and scientists would be laid off. Others were to leave when their units were sold. A core of approximately 20 engineers would remain, but they would be looking for jobs, inside Varian or out, as soon as they finished their current project.

"Here we had a group of fundamentally smart people who had solid backgrounds, but it looked like all our jobs could soon go away," he said. So he had struggled for several weeks to figure out what they could do of value to the company.

One Saturday in April 1990, the answer came to him: medical electronics. Varian had a growing business in linear accelerators and the associated imaging equipment used for cancer therapy. Radiation therapy accelerators use high-power microwaves; his group had been working in low-power low-noise microwave circuits. Although the end product was very different, the basic skills and background in electromagnetic theory required were not so dissimilar. His group also had experience in imaging, having built GaAs charge-coupled devices (essentially, TV cameras on a chip) for missile guidance.

In spite of his boss's reaction, Zdasiuk was sure he had something, and in fact a few days later he was given the go-ahead. To seed the effort, Zdasiuk brought a group of five medical device researchers from another laboratory at the Varian Research Center into his organization, and began studying this new field.

Varian Associates Inc.

Zdasiuk, whose doctorate is in applied physics (Stanford University in California) and BASc is in engineering physics (University of Toronto), went to every medical technology meeting he could. He attended local Chapter meetings of the IEEE Engineering in Medicine and Biology Society. He went to meetings held by such organizations as the American Association of Physicists in Medicine, attended the International Particle Accelerator Conference, took several short courses, and traveled to assorted other conferences on radiology and radiation therapy. He subscribed to half a dozen new journals and read "everything I could get my hands on." He encouraged his subordinates to do likewise.

On average, since the transition began, these Varian researchers have spent more than four weeks a year at conferences and short courses. Many are also taking classes in computer programming, as medical device research requires a strong software background. The budget was there. "Education is inexpensive compared to hiring new people," Zdasiuk told *IEEE Spectrum*.

Intellectually, the transition was not so difficult. "A basic physics and electrical engineering background can take you a long way," Zdasiuk observed. The engineering ego had a tougher time. The Varian researchers had built reputations, individually and as a group, in III-V semiconductor research. "We were recognized for our work in III-V materials, solar cells, and microwave circuits and had won several awards," Zdasiuk said. "That is no longer the case. We're starting all over again, and no one knows who we are. I am sometimes a little envious of my former colleagues."

Still, even this cloud may have a silver lining. "Maybe people get too concerned about their reputations," he said. Only two of Zdasiuk's original group that began the transition did not happily complete the jump to medical research.

But overall, Zdasiuk and his remaining researchers are happy in their new world. It has a team spirit and friendliness, sometimes foreign to the defense research environment, he indicated, that comes of working together on a clear goal—a cure for cancer.

"In defense," he said, "people were focused on their own little pieces of a system, and not many people got to see the overall picture. There was a lot of competition for contracts; even the sources of funding were often obscure and closely guarded. I think that secrecy made people a little paranoid at times. In the medical business, control of proprietary information is important, but everyone, engineers, secretaries, people on the manufacturing line, right to the janitors, all seem to have a sense of purpose."

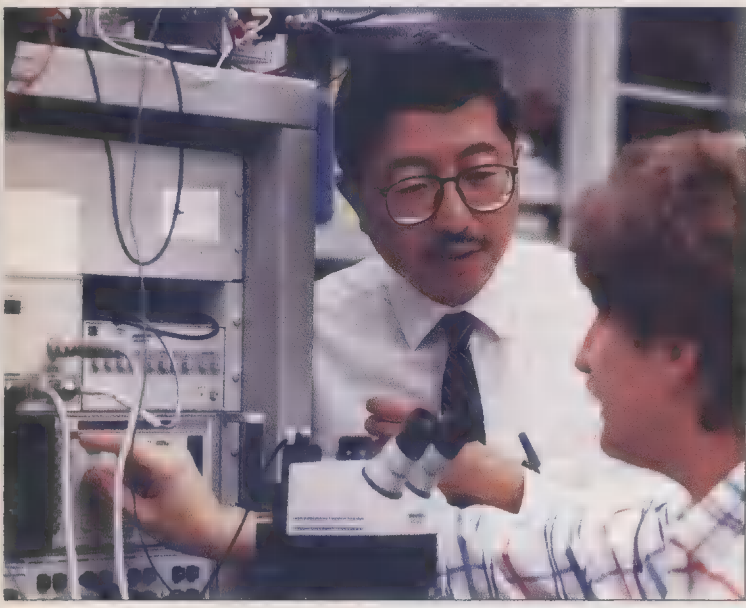
While the basic math and science in medical and defense research may be similar, there are differences. The time horizon is shorter; the engineers are looking one to three years into the future instead of 10–20 years. As a result, they find that they have to develop systems using available components, rather than developing entirely new technologies. "This is not necessarily less challenging," Zdasiuk said, "it is just a different challenge."

Without the support of government contract overhead, the group has become much more cost conscious. They have become more multifaceted and skilled at systems engineering, instead of working on a small piece of a system defined by someone else. They have had to learn to work with mechanical and software engineers, marketing people, and end-user customers.

But concern for reliability is unchanged. If anything, it has grown. After all, Zdasiuk told *Spectrum*, a malfunctioning radiation therapy device could seriously harm or even kill a patient.

Zdasiuk's biggest surprise in making the transition to the commercial world was a pleasant one. "I expected the work wouldn't be as interesting, though I was willing to give it a try. It turned out to be every bit as interesting, and I have a deeper appreciation of the importance of this work. That makes me happy."

His advice to other defense engineers: "Be flexible about what you do and how you see yourself, and if you have an opportunity to learn something new, take it."



Rockwell Interional Corp.

CHEUNG: targeting dual-use technologies

For the last two years Derek Cheung has been moving into commercial applications without leaving his desk or abandoning his areas of research. He is director of high-speed electronics at Rockwell International Corp.'s Science Center, Thousand Oaks, Calif.

Rockwell for years has had a good chunk of commercial business in its mix, including automotive products and chips for fax-modems, factory automation, and telecommunications products. Now its defense work is declining, from a peak of 55 percent of total revenues in defense in the late 1980s to 27 percent today.

A shift in emphasis was urgently needed, and the change filtered through to Cheung in 1990. By then 44, he had worked for the corporation's research arm since 1975, mainly on optics and gallium arsenide electronics, which he developed for use in military radar and secure communications. Nowadays he supervises a group of 36 researchers, who two years ago spent all their time on defense projects but at present put about a third of their efforts into commercial research.

The engineers and scientists who altered their research thrusts were eager to do so, Cheung told *IEEE Spectrum*. As they enjoy a shorter feedback cycle and a lack of classification restrictions, "it may be that the people still doing defense work are a little jealous," he said. (Also enviable is improved positioning for other commercial job opportunities later.)

The group who switched still works on GaAs circuits, but not for defense applications. Instead, the high-performance chips are aimed at digital cellular phones, global positioning satellite system receivers, wireless local-area networks, and high-performance analog-to-digital and digital-to-analog converters for radios.

Cheung has had to learn some new skills and teach them to his group. (His doctorate in electrical engineering from California's Stanford University dates back to 1975.)

"We have a new consciousness about timing because the development cycle is shorter," he said, "also about whether some device we are developing will be manufacturable. And cost-consciousness is greater."

Moving into a different world has required a mental refocusing as well. Cheung said he has had to unlearn the "program mentality." The climax of your work in the defense world, he explained, is winning a contract for a development program; but outside, it is the successful introduction of a product.

Said Cheung: "A lot of worthwhile technical problems need to be solved in the commercial world, a lot more than we expected. Opportunities are out there."

ASH: technology scout

Ivan Ash contacted 350 employers in the Baltimore and Washington, D.C., area after being laid off in 1991 by Fairchild Space & Defense Co., Germantown, Md. Only a handful called him in for an interview. None offered him a job. He withdrew his retirement savings to finance his search, and kept looking.

Then early this year the 52-year-old Ash, along with 400 other engineers, applied for a job advertised in *The Washington Post*. The employer was the Arbitron Co., the national radio and TV ratings service. It was looking for a technology scout to keep it apprised of technologies that will impact the radio, television, and cable industries, and hence the ratings services, in the future.

Ash, who has a BS in engineering science from Marshall University in Huntington, W. Va., and an MS in electrical engineering from Purdue University, West Lafayette, Ind., was invited in for an interview, along with eight other engineers. Arbitron's approach was unique—in a second interview he had to give a 60-minute technical presentation.

This was Ash's chance to shine. Throughout the 20-plus years of his career he had honed his presentation skills. As an Army Contract Officer's Technical Representative, in Washington, D.C.; as a researcher at Southwest Research Institute in San Antonio; as director of optical systems at Harris Corp. in Melbourne, Fla.; and as program manager of fiber optics and telemetry for Gould Ocean Systems Division in Glen Burney, Md., he had regularly made technical presentations to his bosses, to program managers, and to corporate management.

Jim Pickerell

Ash got the job. Now, he spends his time investigating a broad range of technologies and applications, from his specialty, fiber optics, to computer systems, to broadcast technologies (terrestrial and satellite), to cable television, to consumer electronics. He presents his findings regularly to company management, writes assessments of new technologies, and proposes corporate directions. He took a pay cut of about 10 percent from his most recent defense position, but overall, he told *IEEE Spectrum*, "I'm better off. I love this job."

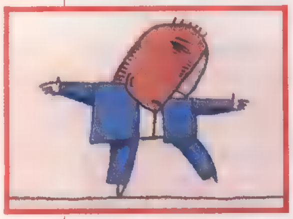
He has given up little in technical challenge, he said. Covering a broad range of applications and technology "draws on every bit of breadth and depth I'd developed in my career and pushes me beyond that."

Ash is considering taking a few computer courses and perhaps some other classes that relate to his new job—his new employer would pay—in, for example, satellite communications and the integrated-services digital network (ISDN). Meanwhile, he persists in a habit that he thinks was critical to his landing this job: "I'm a curious fellow," he said, "I read a lot, in a wide range of areas."

For engineers still in defense, he has this advice: "Don't sit on your duffs, start looking for a commercial job now before you have no choice. Emphasize your basic skills, the breadth of your knowledge, and your understanding of people."

Companies in profile

Approaches to conversion include acquiring new technology as well as selling to the civilian branches of government



For companies that have depended largely on military business for their livelihood, the routes to conversion are diverse. Some have found high-volume commercial applications for their military technology; others have acquired commercial companies to broaden their base. Still others have obtained partners to provide funding for commercializing their expertise. There have been mistakes and misjudgments along the way, and there has been the wrenching problem of changing mindsets from structured military ways to laissez-faire competition. Here, executives of companies from California and New England to Europe and Israel explain their strategies and describe their successes.

Thomson-CSF: microwaves for toll systems

In six years of pursuing programs that convert defense technology to civilian uses, Thomson-CSF has scored big. Most strikingly, the huge French defense electronics company claims it is No. 1 in worldwide sales of air traffic control systems. Today civilian products earn 20 percent of Thomson-CSF's revenues of 35.2 billion FFr, and that portion is likely to grow.

For the future, the company is betting on such areas as electric vehicles, automated microwave toll collection systems for highways and bridges, asynchronous transfer mode (ATM) switches for broadband communications, and data- and image-processing technologies.

These are not easy times, however. The French defense budget is falling steadily, from a peak of nearly 4 percent of the gross domestic product in 1987 to an estimated 3.2 percent next year, according to the Congress' Office of Technology Assessment, Washington, D.C. Jean-Marc Poinsignon, director of planning at Thomson SA, the parent and holding company of Thomson-CSF, was one of three company executives who spoke to *IEEE Spectrum* in Paris. He said that Thomson-CSF has a long record of restructuring in Europe as a result of real and anticipated cuts in defense spending. About 250 000 are employed in the French defense industry, and 20 percent could be laid off in two to three years, according to Poinsignon. (He admitted, though, that reliable data are hard to come by.)

The first attempt to diversify was to apply the company's radar and display know-how to civilian air traffic control (ATC). A standout here is its Trac 2000 radar, intended for terminal and en-route control and the first radar to incorporate a fully transistorized emission-stage transmitter. A recent success is an order, worth several hundred million French francs, from Greece for an upgrade of the country's entire air traffic control system.

Half of its R&D spending goes to software development, hard evidence of how serious Thomson-CSF is about this area. For example, to strengthen Syseca, its in-house software company and France's leader in technical software, it bought European and U.S. software companies, one of whom was Alsys Inc., Burlington, Mass. Alsys specializes in Ada, a language developed for the U.S. Department of Defense and favored by the defense and air traffic control communities.

Two years ago ■ task force within Thomson-CSF looked at all its technical capabilities and identified 400 projects worth exploring for potential diversification. Last year 10 projects were chosen for further development, each getting between 1 million and 10 million FFr a year. They include the electric and hybrid automobiles and the automated toll collection systems and ATM switches mentioned earlier.

Cost is the driving force behind an urban vehicle employing a novel electric drive and in development at Auxilec, a Thomson-CSF subsidiary in Chatou, not far from Paris. Delivery of a protoype is expected at the end of 1996. Auxilec is paring costs of materials and using electromechanical commutation, rather than power electronic components. It also relies on generators with high specific power (power per unit volume and weight), building on its experience with the similar generators and engines it sells for aircraft and marine vessels.

A network for interconnnecting local-area networks is also in the cards. Thomson-CSF's Communications and Command Systems Division, Boulogne, is developing it for France Télécom, the national carrier. The basis is the Thompac 2G, an ATM switch originally developed for the French Ministry of Defense for strategic military networks. ATM has dynamic bandwidth allocation to handle continuously varying traffic and can carry voice, data, images, or multimedia. The market target is switching of telecommunications networks at the bit rates of 140 and 155 Mb/s.

Microwaves on the motorway can automate toll collection there and on bridges. Experiments with prototype systems are under way in Orsay-Corbeville and other locations in France (at 5.8 GHz), and a more advanced system, at 63 and 77 GHz, is in preparation. Thomson Composants Microondes in Orsay developed the circuits under its director John Magarshack. He explained that a microwave transponder on the car's windshield intercepts ■ microwave beacon, which picks up the car owner's identification and toll credit status for referral to a central computer. Meanwhile, the car may be moving at up to 120 km/h. The entire transaction takes about 100 ms. Still to be solved is how to handle several cars at a time.

The system utilizes defense-related know-how in microwave system architectures, circuits, and components (notably gallium arsenide and millimeter-wave IC technologies), phased arrays, and wave propagation. "It's a whole new mind set for us," Magarshack told *Spectrum*, adding that the car industry is not an easy market to deal with. "All of a sudden, you have to fight for your life. People say, 'Thomson, who are you?' " he said. "The automobile market is 10 times more secretive than the defense market," he stressed.

SECURITY IN DEMAND. The demand for electronic security systems in Europe alone is growing at the rate of 15 percent a year. Here, Thomson-CSF adapts expertise in military infrared cameras, radar, sensors, fiber optics, and signal processing to build advanced systems involving image capture and processing. The IR and video camera group has formed ■ subsidiary, Thomson Surveillance Video (TSV), in Cergy-Saint Christophe, which is already marketing a new system for detecting forest fires; in essence, it processes pictures from a thermal imager sensitive in the 3–5-μm band.

As to environmental monitoring, Elec-

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tricité de France got Syseca to design and build a system for informing regional administrators about radioactive gas and liquid leaks in nuclear power plants.

Meanwhile, the civilian market requires full service for system operation, not just the bare system. This is "a very big requirement" for a company "used to selling systems," said Gérard Nuzillat, vice president of Thomson-CSF's corporate R&D, sensors, and components department in Paris.

Indeed, in the last year or so, Thomson-CSF has been offering various technical services to the business community, including the design and installation of large fixed and mobile telecommunications systems, signal processing for industrial purposes, and antenna and radar design.

—Gadi Kaplan, Senior Technical Editor

Hughes Aircraft: taking intelligent risks

In the late 1980s, growth in his company's defense business was slowing sharply. Malcolm R. Currie, then Hughes Aircraft Co.'s chief executive officer, was concerned that military contracts had dropped to a 5 percent growth rate after several years of surging ahead in dollar terms by almost 20 percent annually. He decided that Hughes should cultivate other sources of revenue.

At that time, Hughes' business was 80 percent military and 20 percent nonmilitary, the latter largely in satellite communications. Its total annual revenues were US $7.4 billion. Currie set a goal of changing the ratio to 60/40 by 1995 and 50/50 by 2000. Toward that end, he called on Robert J. Dankanyin, a corporate vice president who was also assistant group executive for the Space and Communications Group, to head up a new corporate diversification organization.

WHAT DIVERSIFICATION MEANS. Dankanyin began by defining what diversification meant to his company: expanding Hughes' business base outside its core concerns into potential growth areas where the company had a unique competitive advantage—one that could be sustained over the years.

The Hughes strategy has worked. In its 3 1/2 years of existence, the diversification program has brought more than 100 civilian products to various stages of development.

At the outset, Dankanyin identified two areas of interest—what he calls "green fields" and "leap forward" markets. He thought that the company should cultivate its green fields, in other words, exploit civilian markets where it is at home with both technology and distribution channels. For example, Hughes is one of the world's largest providers of air defense systems. A natural outgrowth of that kind of product is air traffic control systems.

"Air traffic control systems are sold to governments; we know how to sell to foreign and domestic governments," observed Dankanyin. "They are big system integration jobs; we know how to do that. That's a form of diversification that's important but not too far away from our comfort zone." So far, the company has landed contracts for air traffic control systems in Canada, South Korea, and Germany.

At the opposite end of the spectrum, leap-forward markets—those in which Hughes has proprietary technology but little experience—hold out large rewards but are fraught with risk. So Dankanyin decided to enlist help and guidance through licensing, acquisitions, and joint ventures.

A case in point is Hughes' sound retrieval system. This technology allows listeners to hear three-dimensional sound even while changing position with respect to a pair of loudspeakers; the sound seems to emanate from areas outside the physical limits of the speakers. The secret is patented signal-processing circuitry that restores spatial cues present in the original audio signals.

Rather than attempt to develop marketing and distribution channels on its own, Hughes licensed the technology. Tokyo's Sony Corp. and General Electric/RCA now offer it in their high-end television sets.

SELECTIVE ACQUISITION. In other cases, Hughes acquired companies selectively to expand its technologies into the commercial world. In 1991, it bought ST Systems Corp., Reston, Va., better known as STX. Selling scientific and engineering services and computer systems, this company complements Hughes' capability in software for command and control, air defense, missile guidance, radar, and signal processing.

With an established position as a large private owner-operator of communications satellites, the company turned to acquisition to expand in that business, too. In its view, small earth stations—very small-aperture terminals (VSATs), with antennas less than a meter across—should do very well as a basis for private wide-area communication networks, but it found it less expensive and faster to buy the VSAT operations of M/A-COM Inc. than to develop and manufacture the terminals itself.

CONVERTING LIGHT VALVES. A joint venture was how Hughes chose to diversify the liquid-crystal light valve technology developed for large military video and graphics displays. In September, Hughes and Tokyo's Victor Co. of Japan (JVC) joined forces to manufacture and market large-screen projection systems.

One-of-a-kind military systems based on liquid-crystal light valves cost hundreds of thousands of dollars. Hughes managers reasoned that in high-volume production (tens of thousands), they could lower that figure to tens of thousands and make it attractive for business uses like videoconferencing. And in very high volume production (hundreds of thousands), the product cost would be measured in thousands of dollars—within the range of consumers.

"It was obvious to us that the cost of implementing a factory to build liquid-crystal light valve consumer products and setting up a distribution network would far exceed the cost of product development," Dankanyian said. "So we needed a company like JVC to bring attention to the results of our R&D with their high-volume, low-cost manufacturing and worldwide distribution network."

Somewhere between green fields and leaps-forward is Hughes' automotive business. Here, Hughes can rely on its parent, General Motors Corp., for help in getting products based on defense technology to

Hughes' displays are at work at Electronic Data Systems Inc.'s Information Management Center.

Hughes Aircraft Co.

market. A head-up windshield display of instrument readings will soon appear in Oldsmobiles and Cadillacs, a radar has been developed for adaptive cruise control, and an inductive charger is in the works for electric cars, for example.

Any problems in converting? Yes. "I think cultural change has been the most difficult part," Dankanyin told us. "Becoming market-driven, for a high-tech company, was a very difficult change. Our engineers and managers have had to convert their mindset—no more concentrating on pure technology; now they ask 'What technology does the market need?' "

—George F. Watson, Senior Editor

M/A-COM: slim but ready to grow

Three years ago, when Thomas A. Vanderslice became its chief executive officer (CEO), M/A-COM Inc. had a military-to-commercial business ratio of 90/10. Defense realities were changing, though. So the new CEO set about reshaping the Wakefield, Mass., supplier of microwave and RF components and connectors. Unprofitable operations were sold, the commercial base was expanded, and much of the company reorganized.

Markets such as telecommunications and cellular systems, commercial radar, and navigation systems are the new focus, according to Bill Petry, strategic marketing director. "We have to pay careful attention to our government and defense accounts," he stressed to *IEEE Spectrum*, "but there aren't the same growth opportunities there."

Revenues are leaner: in 1991 they were US $382 million, down from $441 million when Vanderslice took charge. But profits are much fatter, having gone from $178 000 in 1989 to about $31 million last year.

M/A-COM basically applies defense "technology competencies" (Petry's words) to commercial opportunities. In some cases, little change may be needed. It may sell military microwave components directly into commercial markets, with equal stress on quality assurance but with lower-cost packaging and less test documentation.

All the same, to sharpen its focus on its core microwave components (which range from gallium arsenide wafers to ICs, multifunction chip sets, and complete subsystems), M/A-COM has sold off some operations and has bought or is looking into others. Gone, for instance, are production facilities for microwave high-power amplifiers, transmission equipment, and radar-antenna subassemblies. Acquired earlier this year was a European company, Greenpar Ltd., and in negotiation is a deal with a French communications company.

Greenpar is a $25-million-per-year manufacturer in Harlow, Essex, whose low-cost connectors for commercial RF and communications systems complement M/A-COM's line. Greenpar in turn gets an opportunity to sell its products in the United States and along the Pacific Rim.

M/A-COM Inc.

A M/A-COM engineer measures gallium arsenide ICs destined for wireless telephones.

Another M/A-COM move could yield a cross-licensing agreement with French joint-venture partner Axon Connect SA, Montmirail. The deal would allow M/A-COM to make and distribute Axon's cable and connector products in the United States, and Axon to sell M/A-COM products in France.

Still, in branching out from its defense-dominated business, M/A-COM's biggest successes lie in wireless communications and cellular base stations, in Petry's view. In the first area, the company won a sizeable development contract from AT&T in September; it will assist in advancing AT&T's technology for the personnel communications network (PCN), whose pocket-size wireless telephones will keep people almost anywhere in touch. M/A-COM will design and manufacture a 6-GHz microwave module with two-way calling.

GROWTH FROM DEFENSE. For cellular base stations, the company supplies a range of components that grew from defense-oriented technologies—from amplifiers to high-performance delay lines, power dividers, and switches. Petry won't talk dollars, but characterizes commercial base stations as "a real nice business for us in '91 and '92."

The push into these communications markets has the company looking for more engineers. "We have more [cellular and wireless] opportunities than we can address with our current staff," Petry said.

IC designers are in short supply, especially those with experience in concurrent engineering, who can design for manfacturing and test needs. But "it's very difficult to recruit people with those skills now," Petry reported. "We have to grow our own." The focal point for most of the IC design talent is a recently formed integrated design center at M/A-COM's GaAs foundry in Lowell, Mass.

M/A-COM's biggest surprise in reorienting itself was how fast commercial opportunities develop into product requirements. Hence the importance of concurrent engineering, Petry said. "You have to be prepared to ramp up very quickly," he told *Spectrum*. "The team that works on product development has to stay with it into production."

The other main challenge of nondefense business is the need to get products to market as economically as possible. And "as soon as you get a product into production, you have to redesign it for cost reduction and quality improvement," *Spectrum* was told.

As for risks that may accompany the haste to diversify, M/A-COM has learned that one of the most critical is forgetting about the defense customer. To avoid that error, it has changed from a product-line organization into a "market-facing" one. The new organization was created by splitting the Microelectronics Division, which accounts for more than 50 percent of revenues, into three sectors: government, commercial, and operations.

"At the front end of the relationship, customers need to work with people who are like-minded," Petry said. So military and commercial customers deal directly with the appropriate people at M/A-COM. For example, the side facing the government market includes all the test and documentation personnel that only government customers want.

Operations lies between the two other sectors. Its people decide how to manufacture the products wanted in the most cost-effective way, Petry said, while still meeting the other two sectors' needs.

—Lawrence J. Curran, Contributing Editor

Raytheon: practiced in diversifying

Raytheon Co., the fifth-largest U.S. defense contractor, has good reason to ponder the defense spending cutbacks. Its sales last year to the U.S. government accounted for over half of its US $9.3 billion in revenues. Nevertheless, executives like engineering vice president Philip Cheney and marketing vice president Edmund B. Woollen believe that the Lexington, Mass., company confronts the changing times well-prepared. It has diversified over the years, encouraged dual-use technology, and steered clear of unfamiliar sales territory.

Even so, Cheney and Woollen remain concerned about corollaries like the re-employment crisis facing defense workers—especially engineers—as defense budgets shrink. Cheney estimates that in Massachusetts alone 140 000 people work in defense, and many of them may be out of jobs in five years. Raytheon itself employs 13 000 engineers, many of whom may need to be reemployed. Diversification will help, but he sees no easy solutions [''The challenge of peace,'' p. 67].

As far back as the 1960s, Raytheon saw the need for a shift toward a healthier ratio of commercial to defense business. In that decade, it launched an aggressive acquisition program with the purchase of appliance makers Amana Refrigeration Inc. and Caloric Corp., and later bought the Badger Co., a petrochemical plant design firm, and Beech Aircraft, a manufacturer of general-aviation aircraft, among others.

Dual-use technologies are another aspect of diversification. As part of Raytheon's strategic planning, Woollen and Cheney spend 10–15 percent of their time examining technologies that might be useful to both military and commercial customers and would utilize the company's engineering and manufacturing skills.

Whatever the market, the Raytheon way of doing business has certain definable ingredients, and the two vice presidents explore commercial opportunities that have the right elements. One is an opportunity to be a prime contractor for a major project, rather than simply a supplier. Another is a complex engineered product, such as a complete radar system. Also, within the Raytheon division that will sell commercialized products, there must be extensive experience in serving a market, including its peculiar distribution methods. Mirroring its military experience, the company also strongly prefers markets with only a small number of customers, often government agencies.

PAYOFFS. Cheney and Woollen's efforts are beginning to pay off—in civilian air traffic control and personal communications applications, and in scuff-proof tops for Amana's kitchen ranges, for example.

In air traffic control, the aim is to find buyers inside and outside the United States for commercial versions of the radar, digital computer, and display technologies that go into Raytheon's military systems. So far, agencies in Norway, the Netherlands, Germany, and the United States have awarded the company ''tens of millions of dollars'' in new business, Woollen told *IEEE Spectrum*.

In the United States, the Massachusetts company won a $69.8 million award from the Federal Aviation Administration to develop Category II/III microwave landing systems (MLSs). These provide precision guidance for commercial and general aviation aircraft approaching a runway and landing. Categories II and III refer to restricted visibility conditions, with ceilings as low as 30 meters (100 feet).

SAME CADRES. Woollen pointed out that the civil air-traffic control business involves ''a natural use of skills we already have.'' Raytheon's present engineering and manufacturing cadres are quite capable of doing low-cost, fast-turnaround commercial designs, he argued, because contrary to popular belief, defense contracts are ''highly competitive, subject to evaluation by third parties who force contractors to deliver the best value against complex specifications.'' Commercial specifications are generally more relaxed, he said.

In another area, a proposed global telecommunications program teams the company's Equipment Division with Motorola Inc.'s Satellite Strategic Business Unit and Lockheed Corp.'s Commercial Space Co. to compete against other teams in a project Motorola calls Iridium. Handheld portable personal and mobile telecommunications coverage would be provided by a network of satellites in low earth-orbit.

Raytheon would supply the system's main phased-array antennas—it builds similar antennas for the U.S. Air Force in the AN/TRC-170 troposcatter radio system. While Iridium is only prospective business, Cheney said that its potential could be large. The launch phase is set for 1994.

More down to earth, digital switching systems, from a subsidiary bought some 20 years ago, are just entering beta testing at customer sites. Seiscor Technologies, Tulsa, Okla., initially supplied analog switching equipment to local telephone companies, but when digital transmission became essential, Raytheon provided funding to make the transition.

No beta test results are yet available, but as Cheney pointed out, the joint effort is a good example of ''taking our engineering experience in the Government Group and marrying it to Seiscor's knowledge of the market and the phone companies. But their communications guys run the program.''

IS IT AFFORDABLE? Commercial applications may not be able to afford solutions based on advanced military technology. Raytheon engineers learned that after trying for a material for Amana range tops hard enough not to scuff during cleaning.

Amana wanted a harder stovetop that still let sufficient heat from the heating elements reach the surface. Engineers in the

Four countries have bought commercial versions of Raytheon's military radar, computer, and display technologies for air traffic control automation systems.

Raytheon Co.

Raytheon Research Division proposed Alon, a material based on aluminum oxide. The company's Missile Systems Division had used it for Stinger missile nosedomes.

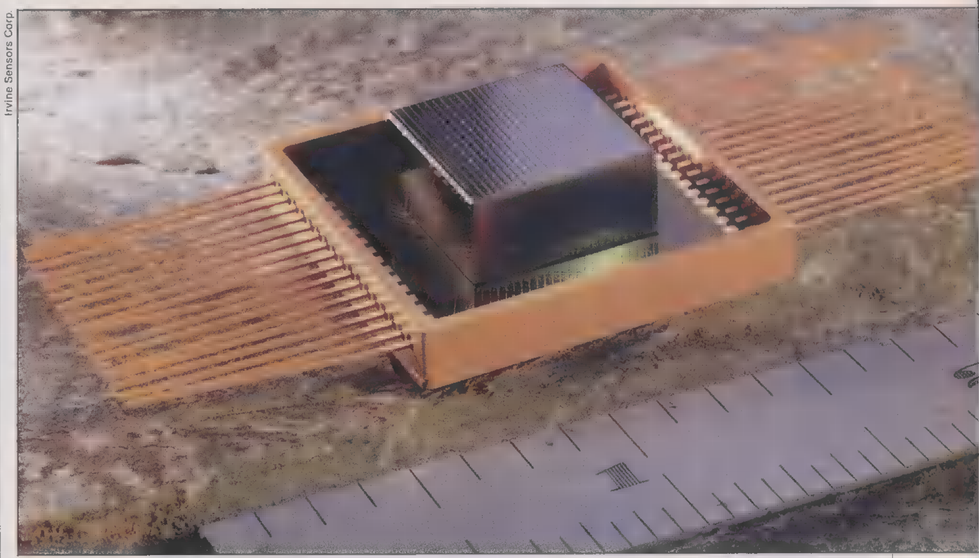
The Alon was superior on both counts to the existing stovetops, Cheney said, but it cost too much for a commercial market. Instead, the Research Division came up with a proprietary spray-on coating that resists scratching and costs an order of magnitude less than the Alon.

NO QUICK FIXES. Neither Cheney nor Woollen will say how converting military technology to commercial use has affected Raytheon's employment, but they pointed out there are no quick fixes. A significant impact on re-employment of engineers may take as long as 5–10 years to become manifest. "It's like starting a new business," Woollen said, "which requires a corporate commitment to stay the course."

The biggest need in transferring technology from military to commercial markets, Cheney said, is a thorough understanding of the market to be served. Raytheon has encountered no obstacles to conversion in the way of technology or corporate culture; but it has bypassed possibilities in those markets unknown to anyone in the company.

Home entertainment is an example, said the marketing vice president: Raytheon may have a good grasp of all the technology required, but none of its commercial divisions has experience in it.

—Lawrence J. Curran, Contributing Editor


Irvine Sensors Corp.

Stacked chips are bonded to a silicon substrate in Irvine Sensors' dense-packaging scheme.

Irvine Sensors: wooing the giants

Irvine Sensors Corp. invented an unusual, highly compact packaging scheme for ICs in the early 1980s. As the work was done for the Defense Advanced Research Projects Agency (Darpa), the company was surprised to learn that the scheme showed promise for low-cost manufacturing of commercial products as well. Cofounders James Alexiou and John Carson figured they would need about US $7 million to set up a factory. But the small Costa Mesa, Calif.-based company grossed less than $2 million annually. (Sales have since grown, hitting $4.2 million in 1991.)

Alexiou and Carson hit on a strategy: get development funding from giant corporations in exchange for a share in Irvine's proprietary technology. They have only just succeeded. In June, IBM Corp. signed an agreement to commercialize Irvine Sensors' chip-stacking technology, called "cubing" because the stacks resemble sugar cubes. IBM is setting up a Cubing Process Development Center at its Burlington, Vt., location. (Neither partner has disclosed the value of the agreement.) Irvine's president, Kenn Lian, told *IEEE Spectrum* that his firm is close to similar agreements with two other companies and is also introducing, on its own, a smaller, simpler chip stack.

The IBM deal capped a long, intense courtship. "When we started to seek a commercial sponsor, we quickly found that partnering is a rigorous process," Myles F. Suer, Irvine's director of marketing, said. "Companies in the commercial world won't spend a nickel unless you've got something proven to show them." This was a far cry from dealing with the Department of Defense, which would fund promising technology even if it was still conceptual.

Irvine persisted, however, and eventually satisfied IBM. The agreement gave a boost to the company's 35 employees as well as to its fortunes. "This is an exciting time for us," said Lian, who has been with Irvine since 1982. He expects to see a profit—the company's first in 10 years—next year. And Irvine shares have jumped in value from pennies to dollars.

The cubing technology evolved from work sponsored by Darpa and later by the Strategic Defense Initiative office. Irvine was developing an imaging infrared sensor that was to detect ballistic missile launches by scanning the earth's surface from a satellite. Irvine's chief scientist, John Carson, is an infrared imaging specialist. He wanted to process signals from the infrared detector array as close to it as possible in order to speed signal processing, reduce interference, and save space and weight.

DENSE MEMORIES. Carson devised a way to mount stacked IC cubes directly on the detector array and run chip-to-chip interconnections along the exposed faces of the cube. Irvine proceeded to develop the method. "Then, about '83, people like Craig Fields at Darpa got very interested in the possiblity of using our technique for memory," Lian recalled. "They wanted extremely dense memories for [Department of Defense] applications."

Irvine received a contract from Darpa to apply stacking to memory chips, in parallel with other high-density packaging contracts at General Electric Co. and Texas Instruments Inc. Its new contract required Irvine to hire an independent manufacturer to analyze the manufacturing process and estimate capital and operating costs.

EYE-OPENER. The process looked expensive in an R&D environment. "But we determined from the [independent manufacturer's] report that we had a good shot at being commercially competitive," Lian said. "That was an eye-opener."

Irvine began to seek strategic partners for cubing technology, concentrating on commercial computer manufacturers. In his talks with prospective partners, Irvine Sensors emphasized the benefits of placing chips closer together: lower I/O drive currents, power dissipation, and signal settling times because of the shorter lines and lower capacitance and inductance; greater reliability because wire bonds and other interconnect junctions are eliminated; and smaller systems because of the greater chip density. These properties could be improved even further if ICs were designed with three-dimensional stacking in mind.

To demonstrate the concept, Irvine produced stacked 1M-bit dynamic RAMs for both Unisys Corp. and IBM. The stacks contained 20 to 70 ICs, interconnected on 0.25-mm centers and packing 40–50M bits into a "cube" measuring about 12.5 by 25 by 6.25 mm. Suer told *Spectrum* that up to 100 chips can be stacked.

In addition to securing a partner for its cubing technology, Irvine recently raised several million dollars for commercialization of a shorter version of the memory cube. These "short stacks" contain up to 10 chips and will fit into standard packages like flatpacks and multichip modules. Irvine Sensors' managers believe that short stacks, with their more conventional form factor, will gain quick acceptance for supercomputers, massively parallel processors, and memory cards where overhead space is inadequate for full stacks.

—George F. Watson, Senior Editor

U.S. Customs Service will use Westinghouse's tethered-aerostat radar to detect drug smugglers.

Westinghouse Electric Systems Group

Westinghouse: it's all convertible

Defense is still the core business of Westinghouse Electric Corp.'s Electronic Systems Group, affirmed a key executive, R. Noel Longuemare. "But we see a great opportunity to expand that business into non-DOD [Department of Defense] markets because almost anything we do in electronics—our main business—can have non-DOD uses," he continued. Longuemare is vice president and general manager of the Systems Development and Technology divisions, part of the Baltimore, Md.–based group.

The group's goal is for nondefense business to yield 50 percent of its revenues in 1995, without any falling off from current defense business levels. It was charged with the conversion effort in 1988 and in 1989 formed some specifically commercial systems divisions; these now number five and employ about one-fourth of its workforce. (It was also Westinghouse's goal to retain both engineers and production workers despite shrinking defense budgets.)

The Electronic Systems Group's strategy is to develop other governmental and commercial markets that are closely related to its military products. Acquisitions are chosen to complement group skills and technologies, which range over air traffic control and airborne radars and antisubmarine warfare systems.

In 1991, the group accounted for some US $3.2 billion of overall Westinghouse revenues of $12.7 billion. About a third of that contribution came from non-DOD sources, Longuemare said, an indication that the effort is beginning to pay off.

But while diversification is succeeding, the move has not prevented downsizing. Longuemare said 1400 were laid off across the board in 1992, reducing the group headcount to about 15 400.

To date, the Electronic Systems Group has found commercial uses for variations of its mainstay military ground-based surveillance radar, airborne radar and forward-looking infrared (FLIR) systems. It is also building capabilities in the transportation automation business, electronic control of access to secure areas, electric vehicle propulsion, and bar-code-based mail processing.

DRUG INTERDICTION. Of all these diversification programs, airborne radar expertise has delivered the biggest reward to date. Last February, the U.S. Customs Service awarded a team headed by the Westinghouse group a $100 million contract for a tethered aerostat radar system for use in the drug war. The Westinghouse group is the prime contractor, with TCOM L.P., Columbia, Md., supplying the 22-meter-long aerostats (balloons), which carry a 1400-kg radar payload to an altitude of 15 000 ft.

The team is to construct sites and install and support four systems, to be used to detect and track drug-smuggling aircraft and boats crossing the southern U.S. border or entering the Bahamas. The radar is a version of Westinghouse's ground-based military surveillance model with enhanced tracking, signal data processing, and beacon target extraction. Longuemare said the commercial version is essentially the same as the the system that Westinghouse supplies to the military.

Like other defense firms, Westinghouse has also used acquisitions to diversify. In late 1990, the company acquired Innovative Computing Corp. (ICC), whose knowledge of the trucking industry and software complemented its own expertise. Located in Oklahoma City, Okla., ICC specializes in management systems for use by the trucking industry.

Since becoming a subsidiary of the Electronic Systems Group, ICC has introduced a new shipment-management software program. Called Westinghouse Sure Shipping, it has cut the cost of truckload transportation by 10 percent at Reynolds Metals Co., Richmond, Va., its first user. Sure Shipping automates previously manual functions for large-scale shippers, including planning and optimizing loads, selecting carriers and monitoring performance, and keeping tabs on the location and status of shipments. ICC gives Westinghouse "market knowledge and a customer base that we didn't have before," Longuemare said.

Another late 1990 acquisition was seen as an opportunity "to apply our capability in electronics, sensor development and command and control monitoring" to a broader market, he said. According to Longuemare, Schlage Electronics, Santa Ana, Calif., now a subsidiary of the group's Commercial Systems Divisions, pioneered development of proximity-type access-control devices, based on identifying radio-frequency signals, and has more than 40 000 installations in 56 countries.

Yet another effort involves electric vehicles. The Westinghouse group is developing a cost-competitive propulsion system for electric vehicles. Beginning next month, the system will be evaluated in the first of 10 Chrysler minivans, most of which will be used by Baltimore Gas and Electric and the State of Maryland. Expertise gained as a supplier to the U.S. Navy of the Mark 48 and 50 torpedos helped solve some problems posed by the electric drive, said Longuemare.

BAR-READER. Another nondefense government agency Westinghouse has cultivated is the U.S. Postal Service. Two years ago, the service awarded the Electronic Systems Group a $14.2 million contract to manufacture 1313 wide-area bar-code readers, which make very fast work of processing the mail. The Westinghouse machines read a bar-coded address almost anywhere on an envelope, not just in the lower right-hand corner, as earlier readers do.

The military technology built on here is borrowed from the Airborne Warning and Command System (Awacs), a radar the group sells to the Air Force. The sensors, signal processing, and algorithms involved help optical character-recognition equipment decipher poor handwriting and discriminate it from smudges, much as they help Awacs tell targets from clutter.

—Lawrence J. Curran, Contributing Editor

Qualcomm: timing is everything

What Irwin M. Jacobs and Andrew J. Viterbi had in mind when they founded Qualcomm Inc. in 1985 was selling products and R&D services to the U.S. government, just as they had in previous enterprises. Their expertise was—and is—in digital wireless communications.

The company found acceptance from the start. In its first fiscal year, ending in 1986, it took in about US $2 million in sales, almost all from the government. Next year, sales climbed to $6.5 million—but by then 20 percent was to commercial customers. Today, nondefense companies contribute 90 percent of Qualcomm's approximately $100 million yearly revenues.

Commercial business did not rank higher than military with Jacobs (now chairman and chief executive officer) or Viterbi (now vice chairman and chief technical officer). Rather, they accepted a small contract, by chance commercial, for a technology in which they were expert: spread-spectrum communications, which till then had served only secure wireless communications and antijam radar for the military.

MESSAGES TO TRUCKS. That technology has become Qualcomm's bread-and-butter business: a product and service called OmniTracs, which uses spread-spectrum techniques to send messages by satellite between trucking company dispatchers and drivers. Qualcomm supplies the equipment and runs the servce for its customers.

At the same time, the company is commercializing spread-spectrum techniques for the burgeoning market in cellular telephony and for developing nations that want to leapfrog into 21st century telecommunications. (Spread-spectrum signals are transmitted over a wide range of frequencies at low power and collected into their original frequency at the receiver. They are as unlikely to be intercepted by a military enemy as to interfere with signals from other users of the same frequencies. They open up crowded spectra to greatly expanded use.)

Some 30 000 trucks in the United States have OmniTracs installations. Their drivers are in continual e-mail–like contact with their dispatchers, who are automatically apprised of where the trucks are. The users report improvements in fleet use, cargo management, and delivery time, as well as in customer satisfaction, driver morale, and dispatcher productivity.

NO INTERFERENCE. Andrew Viterbi told *IEEE Spectrum* how OmniTracs got started. "A supplier of two-way line-of-sight radio services for truckers came to us in 1985 as the people who could build a satellite communications system for them," he said. "We saw the potential of spread spectrum for this kind of service. We could operate over leased satellite transponders. Sweeping over portions of the 12–14-GHz band, spread spectrum wouldn't interfere with existing traffic."

But the supplier, Omninet Corp., ran into problems in getting financing for continued work by Qualcomm. By this time (1988), however, Qualcomm's management and engineers recognized the promise of the concept. So through a transfer of Qualcomm stock, Jacobs and Viterbi arranged to buy Omninet and its experience in the transportation industry, then arranged their own financing for further development. "We acquired our customer; that got us started in the commercial business," Viterbi said.

More recently, Qualcomm started adapting spread-spectrum techniques to wireless cellular telephony. The genesis was a request by Pacific Telephone, Nynex, and Ameritech that the company explore spread spectrum as an alternative to analog and time-division multiple-access (TDMA) digital transmission. "Their investment was small, but it did give us the impetus and encouragement to continue," said Viterbi.

Qualcomm engineers used the same digital coding scheme they had patented for OmniTracs—code-division multiple-access (CDMA). With TDMA, a caller stays tuned to one recurring time slot. With CDMA, a caller stays tuned to a unique code and accepts only bits identified by that code, making more efficient use of available time and frequency. Because of this and other engineering feats, Viterbi said, CDMA offers 10–20 times the capacity of analog cellular transmission; TDMA only triples it.

POCKET-SIZE PHONES. Viterbi views CDMA's future as being not just in mobile cellular telephony but also in personal communication networks (PCNs), in which people can stay in touch, almost wherever they may be, by means of pocket-size wireless handsets. Viterbi believes that CDMA will unleash a mass market.

Events are moving fast for Qualcomm, even though it started far behind TDMA developers. This year, the Federal Communications Commission granted it license to conduct experiments in personal communication services in the 1850–1990-MHz band. The company scored a coup on Sept. 30 when US West's NewVector Group opted for CDMA to upgrade its analog system in Seattle, Wash., while other carriers had either opted for TDMA or remained undecided. Meanwhile, Qualcomm has licensed CDMA to such communications giants as AT&T, Motorola, Northern Telecom, Nokia, and Oki Electric.

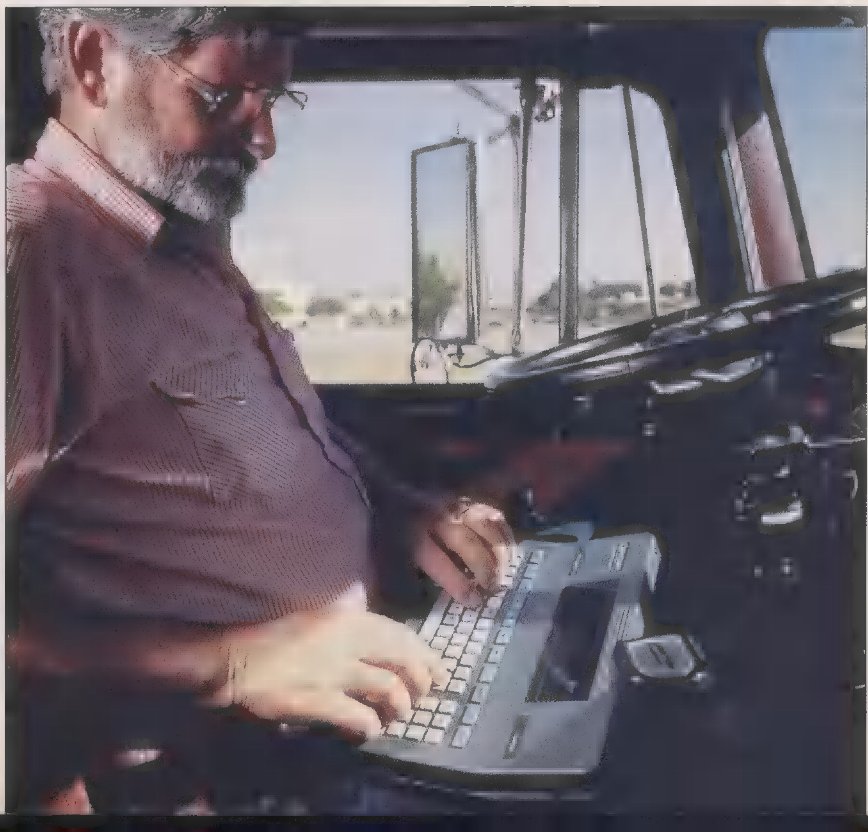
Such a breakneck pace has had its tribulations. One of the biggest has been financing. Money has been tight from time to time, and the specter of bankruptcy flickered more than once before Qualcomm's management in the early days.

SELLING MEANS EDUCATING. Marketing to commercial customers is almost as tough as finding funds. Selling to them also means educating them, proving to them that a new technology will improve their bottom line.

As for the future, in a joint venture with Loral Corp., New York City, Qualcomm is developing a communications system that will put 48 satellites into low earth-orbit. Slated for service in 1997, Globalstar will extend mobile communications outside the cities. "It brings wireless personal communication anywhere in the world," Viterbi said. "For developing countries in Africa and Asia, it can provide virtually all their communications."

—George F. Watson, Senior Editor

A driver uses Qualcomm's spread-spectrum radio to communicate with a dispatcher.



Qualcomm Inc.

Israel: defense firms gird for peace

Leading Israeli defense manufacturers are pushing even harder to convert to civilian applications. Recent years have seen a fall in the country's military spending. In constant 1988 U.S. dollars, expenditures more than halved from 1984 to 1991, dropping from US $8.4 billion plus to $3.9 billion, reported the *SIPRI Yearbook 1992* put out by the Stockholm International Peace Research Institute.

From interviews with engineers and scientists who are instrumental in these conversions, *IEEE Spectrum* learned that the efforts converge, by and large, on four civilian areas: telecommunications, transportation, and medical and consumer electronics. The interviewees work for Rafael, Elbit, the Israel Aircraft Industries (IAI), and Tadiran.

Rafael, near Haifa, is the Hebrew acronym for the Government's Armament Development Authority. Elbit Ltd., also in Haifa, specializes in electronics and imaging systems for defense and medical applications. Israel Aircraft Industries Ltd., located at Ben Gurion International Airport, is Israel's largest high-technology company, with gross sales of $1.6 billion. As for Tadiran Ltd., it supplies military communications systems from the town of Holon, near Tel Aviv.

Back in 1982, when Rafael formed Galram to focus on technology for civilian purposes, the endeavor was driven by technology, not the markets. Rafael hoped to capitalize on some of its hundreds of areas of expertise, including electro-optics, thermal imaging, image processing, communications, spread spectrum, computers, C^3I (communications, command, control, and information), sensors, and microelectronics. But success proved elusive.

About 18 months ago, therefore, Galram—now a holding company for new ventures—changed its strategy. Its civilian efforts now start in the marketplace, not in the laboratory, explained vice president of business development Ruben Krupik.

Galram favors technically difficult interdisciplinary areas where it may have a clear edge over commercial competitors. For example, it is developing a temporary heart-assist system for use in patients undergoing heart surgery or catheterization. Now in clinical trials, the system employs advanced materials know-how acquired while designing missile and sensor systems for the military [see table].

TACKLING CONSUMERS. If there is one area that probably should be off limits to military electronics companies, it is television sets for the home. After all, just about every U.S. TV manufacturer has been driven from the field by high-quality, low-priced sets from Europe and the Orient.

That may be so, but it doesn't scare Elbit. In June 1991, it formed its Video Products Group, whose targets include TV sets, flat panel displays, and consumer electronics devices. In September, the first of its 25-inch private-label sets were shipped to a distributor in Stuttgart, Germany, for sale in Western Europe. Yet the go-ahead for the program had been given only in January.

Elbit believes it has a good match in consumer electronics for its military video capabilities, which it applies to monitors aboard aircraft, naval vessels, and tanks. And it looks forward to being a player when TV sets evolve into high-definition all-digital multimedia units.

For the first-generation product, Elbit developed both the design and a production plan in parallel. "Such concurrent engineering does not exist in the military," noted development engineer Menachem Wagman, who had worked on military video programs for about 20 years.

As for IAI, the company reportedly has recently suffered a major decline in contracts in refurbishing civilian aircraft. Still, 25 percent of its total 1991 sales of $1.6 billion was civilian, and this portion is expected to grow to 50 percent in just two to three years, a company spokesman told *Spectrum*. Several of its subsidiaries are offering new systems for civilian use.

One is the unmanned air vehicle (UAV) by Malat (the Hebrew acronym for a pilotless aircraft), following recent successful reconnaissance missions in the Gulf War and elsewhere. The company is willing to tailor the UAV to nondefense needs like police surveillance, radioactive emission tracking, and exploring for minerals. To cut costs, the UAV's payload has been lightened by over 80 percent to 90 kg (a radioactive-emission-tracking prototype has already been flown), and the size of its ground control station went from three racks to the compactness of a personal computer. Another is a precision version of distance-measuring equipment for use with aircraft coming in to land. Developed by Elta, an IAI subsidiary, it builds on the aerospace company's expertise in radio frequency, radar, and communications.

A large and growing market is medical electronics for cardiac patients, which Tadiran has targeted with an emergency system for summoning help [see table]. The key element is a wireless emergency button installed in the home, which the patient has only to press to summon an ambulance and to transmit his or her identity and other data to a control center. Stabilized video cameras suspended from a balloon 200 meters above ground—a spinoff from a military system—guide the ambulance through the least congested traffic areas.

Utilizing its spread spectrum expertise, Tadiran also developed radio data communications systems for monitoring and controlling the loading and unloading of shipping containers for merchant ships, and for locating individual vehicles in large fleets on land.

—Gadi Kaplan, Senior Technical Editor

Some civilian systems developed by leading Israeli defense contractors

Company	System(s)	Technologies applied	Status
Elbit Ltd.	TV sets; advanced video products	Monitors for planes, tanks, ships	Manufacturing is under way
Galram (Rafael)	Portable terminal for satellite data communications	Satellite communications; rf; antennas; millimeter-wave ICs (MMIC)	Working prototypes approved by Inmarsat; design for manufacturing is under way
	Temporary heart-assist system	Sensors; materials; computer control	Clinical tests in Israel are under way
Sela Ltd.	Precision (1-μm) semiconductor wafer slicer	Advanced mechanics	Prototype used in Israel for examination of defective wafers
Israel Aircraft Industries Ltd.			
Malat Unmanned Air Vehicles	Unmanned air vehicle (UAV)	Reconnaissance; aerial photography; command and control	U.S. Federal Aviation Administration is setting guidelines for civilian operation of UAVs; 90-kg payload is being tested
Elta Electronics Industries Ltd.	Distance-measuring equipment for aircraft (precision version)	Rf; communications; microwaves	Prototype exists; marketing partner is sought
Tadiran Ltd.	Command and control system for loading and unloading cargo containers	Spread spectrum; time-division multiple access; rf techniques	Pilot system is being deployed in the Netherlands
	Vehicle location system	Spread spectrum; digital communications	Operating in Los Angeles; deployment is under way elsewhere in the United States
	Cardiac emergency system	Communication, surveillance; command and control	Manufacturing and marketing are under way

GEC-Marconi: from fly-by-wire to fun

Although best known for the advanced avionics systems it builds for warplanes, GEC-Marconi, the electronics arm of the United Kingdom's giant General Electric Co. PLC, has always had a presence in the civilian market, most notably in air traffic control and radio and television broadcast equipment.

Today, recognizing that the civilian sector is where the growth is, the London-based company is in the midst of a program to increase its civilian business. According to company spokesman Dexter Jerome Smith, that business, which accounted for only 10 percent of revenues in 1982, is up to 27 percent today, and is expected to grow to 50 percent by the turn of the century.

How will Marconi make the switch? By sticking to what it knows best—aviation electronics—but finding applications for its expertise in that field in the civil aviation sector.

As an example, one technology that Marconi developed for the military but is now applying to civil aviation is fly-by-wire flight controls. With such controls, the mechanical and hydraulic links between the cockpit and the aircraft's control surfaces (ailerons, rudders, and so on) are replaced by electronic databases and wire cabling or fiber optics. The technology was originally developed to enable military pilots to deploy their weapons while flying high-performance aircraft. Many high-performance military planes are inherently unstable and demand a great deal of pilot attention. Fly-by-wire allows a computer to assist and free the pilot for other tasks.

At first glance, commercial airliners seem to be a different story—much easier to fly, rarely executing fast or stressful maneuvers, and without weapons systems. Nevertheless, they can benefit from fly-by-wire flight controls because such controls are easier and less expensive to design, manufacture, and install than conventional controls. They also respond more quickly and accurately to pilot input, are more reliable, and are easier to maintain. Finally, they weigh less—always important to anything that has to get off the ground.

CLEAR VISION. Another area in which Marconi is applying military technology to the civilian market is in enhanced situational awareness systems (ESASs). The term is being used for a variety of systems in which head-up displays (HUDs) are combined with advanced millimeter-wave and/or infrared sensors to permit airliners to operate under visibility bad enough to have grounded them otherwise.

Simulator tests of one such system were recently conducted by Northwest Airlines in the advanced crew station simulator at McDonnell Douglas Corp. in Long Beach, Calif. In those trials, senior pilots found dramatic improvements in maintaining desired flight path and touchdown points over conventional head-down displays.

Although improved landing precision by itself is desirable (it saves money by reducing brake wear), the real benefits of an ESAS are greater safety and fewer flight cancellations or rerouting. According to a recent report published by the Flight Safety Foundation, at least 31 percent of the civil jet transport hull loss accidents that occurred between 1959 and 1989 could have been prevented by the use of systems of this kind.

Another plus of any enhanced vision system that allows flight despite poor visibility is that it enhances revenues, since grounded aircraft generate no income. In addition, Smith asserts, there is the intangible factor of passenger confidence.


GEC-Marconi

The telephone handset also controls GEC-Marconi's in-flight entertainment system.

ENHANCED ENTERTAINMENT. In addition to the fairly straightforward application of military technology to the civilian aviation market, Marconi is also adapting its expertise to civil systems that have no direct military equivalent. Specifically, it has parleyed its experience in multiplexed communications and real-time distributed data processing into the development of a new class of in-flight entertainment package.

While the concept is hardly new (Zeppelin airships carried an aluminum piano, and in-flight movies have been standard fare for many years), the Marconi in-flight entertainment system (IFES) goes beyond anything previously attempted. It provides for a telephone and an audio-video system at every seat. The telephone will incorporate a credit-card reader and the ability to connect with a passenger's personal computer.

In addition, the 72-channel system will include an enroute aircraft position display, indicating the progress of the flight with a small plane moving over a map. The system will also feature electronic games and maps showing the layout of the destination airport, its baggage claim area, information on connecting flights, and so on.

Lead customer for the system is United Airlines, which will have the system built into its Boeing 777s. Those planes, to be delivered starting in 1995, will offer eight simultaneous video programs with multi-language stereo soundtracks; 24 audio programs; and fully interactive passenger services, including the capability to order merchandise for delivery on the aircraft or on the ground. On international flights, passengers will be able to view, select, and pay for duty-free items contained in an electronic catalog.

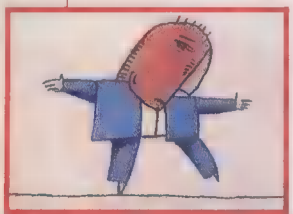
Although 1995 is three years away, United plans to introduce limited versions of this IFES equipment next year. Its contract with GEC-Marconi provides for the installation of equipment in 92 aircraft so that it can offer some of the services to its first-class and Connoisseur-class passengers.

The United contract, worth in excess of US $100 million, includes options for additional equipment, which could double its value. GEC-Marconi is hoping to interest other airlines, especially those with Boeing 777s on order.

—Michael J. Riezenman, Senior Editor

How government can help

Governments might intervene to boost national and local economies as defense funds dwindle and jobs disappear



With the 45-year-long Cold War over and the need for armaments buildup diminishing, how should the Pentagon handle the distribution of its pink slips to defense suppliers? Might laid-off defense engineers be enlisted in the global competition to create industries with high-paying jobs?

Not yet sure how best to handle the contraction of the immense defense production complex it created, the U.S. government faces enormous pressures to downsize quickly, much like its counterpart, the former Soviet Union. Although Congress recently allotted more than US $1 billion to varied forms of conversion assistance, the funding has been criticized as being "random rather than rational," according to industry analyst Jacques S. Gansler [see also "Government must play a role," p. 67]. So far, since 1990, only about $50 million of Federal and state money has been spent to help the defense industry adjust to a more civilian-oriented economy. But Government conversion efforts may pick up as the Department of Defense (DOD), or at least parts of it, struggles to mesh the defense technology base more closely with that of the commercial world.

John A. Adam Senior Associate Editor

"By 2000, I want an industrial base that is as much as possible a commercial industrial base," Nicholas Torelli, a Pentagon official responsible for production resources, told *IEEE Spectrum*. If implemented on a large scale, the moves toward that transition may have repercussions for commercial competitiveness as well.

In the meantime, both the United States and Russia are making big foreign arms deals with such countries as Iran, Taiwan, China, and Kuwait. A $9 billion sale of six dozen F-15 aircraft equipped with missiles to Saudi Arabia will keep the U.S. production line open for three years and preserve roughly 40 000 jobs, according to Joel L. Johnson, vice president at the Aerospace Industries Association of America Inc., Washington, D.C. Since 1987, by Pentagon reckoning, U.S. arms exports have nearly quadrupled, from $6.5 billion to $24.1 billion this year.

In addition, Congress has avoided tough program terminations, like the Sea Wolf submarine and M1 tank, to preserve local jobs during a tough economy. Analyst Gansler estimates the cost for these programs will be $8 billion for this year alone.

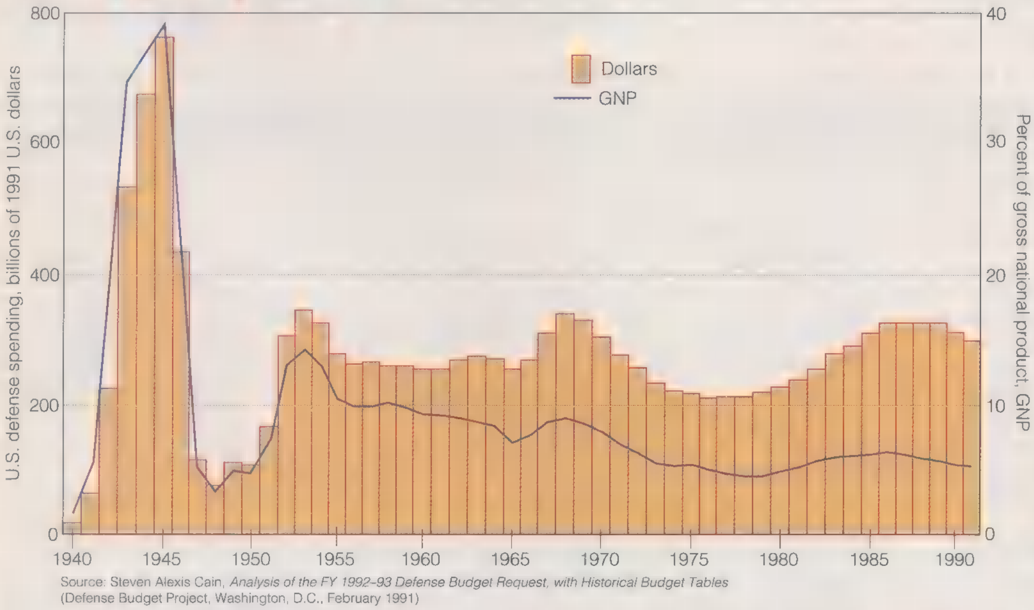
No matter how sound these moves may be, preserving such programs is not likely to be sustained in the long run. To elicit some alternative actions, DOD's bipartisan Defense Conversion Commission (DCC), chartered by Congress, is conducting a six-month study, whose conclusions are due in January. Whether it will produce some consensus on what to do remains to be seen.

HOW BAD IS IT? In fact, the United States has experienced more drastic downturns in the past, especially after World War II [see graph below]. What distinguishes the present defense downturn is that it appears permanent, rather than cyclical, due to the breakup of the former Soviet Union. In addition, unlike the late '40s and '50s, civilian job growth has been disappointing; makers of military equipment are not champing at the bit to move quickly into the commercial economy, which now has tougher global competition.

"If we had a healthy economy, we wouldn't have a defense conversion problem," said David J. Berteau, DCC chairman. Of late, Berteau and about 20 staffers have held more than a half dozen regional hearings from Groton, Conn., to Long Beach, Calif., and received about two briefings daily from companies, think tanks, and state governments. They also examined reports and data supplied by those same sources. Foreign governments, including Russia's, are keeping abreast of the commission's work.

During a 90-minute interview with *IEEE Spectrum* in mid-October, Berteau, who is on leave from a Pentagon job overseeing production and logistics, emphasized that no conclusions on a course of action had yet been reached. He

Defense spending for 1940–91



Source: Steven Alexis Cain, *Analysis of the FY 1992–93 Defense Budget Request, with Historical Budget Tables* (Defense Budget Project, Washington, D.C., February 1991)

U.S. defense spending has seen more precipitous drops, but a few factors, such as economic stagnation, are making this transition more difficult than the one after World War II.

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added that much data, such as that on employment, is inadequate, especially for historical comparisons. In the worst-case scenario, he said, the defense industry from 1987 to 1997 will lose about one-third of its jobs—from 900 000 to 1 million positions. Perhaps half the job cuts have already occurred, he believes, many through attrition.

The real "peace dividend," Berteau told *Spectrum*, "is not those dollars [saved on defense projects] but putting the creative energy and talent [of former defense engineers and scientists] into other problems that face humanity today."

A central question, still unresolved, he said, is "Do you treat the defense industry differently from those in the civilian economy—do defense companies have more of a lien on national money than other businesses?"

AGAINST INTERVENTION. The case against exceptional Federal intervention (rather than the typical retraining and unemployment benefits) has some familiar themes. Why, for instance, should auto workers in Michigan, a state that has a traditional net outflow of taxpayer dollars for defense, pay for transitioning California's defense workers?

Berteau also noted how the synfuels example of governmental technological development in the late '70s missed the market. "We don't want to create a national set of answers for local problems," the conversion chairman said. "We don't want to fix Connecticut at the expense of California or vice versa."

"Every region wants more money," he said. "There's almost a belief out there that the Federal government gets its money from

Some state and local initiatives

A sneeze at the Federal level—a decision to stop one of three production lines, say—can turn into a hurricane at the local community level. So perhaps it is not surprising to see that military-dependent states and counties have acted faster on conversion.

While there is no single recipe for success, according to the U.S. Defense Conversion Commission's David J. Berteau, this article sketches a few options in New York State, St. Louis, and Los Angeles County.

New York State. About 15 percent of the state's manufacturing jobs come from defense spending; with military bases included, nearly half a million jobs here are related to military work. In January 1991 the state's Defense Diversification Program (DDP) was announced by Governor Mario Cuomo in his state-of-the-state address, after a four-month interim study (and survey) by a varied 26-member advisory council.

The goal was to offer DDP assistance to a minimum of 1000 defense-dependent manufacturing firms in the state. As of April this year, more than 700 defense companies have been contacted, often through existing regional extension offices, on the availability of DDP resources.

According to an April 1992 report by the New York State Department of Economic Development, so far US $1.8 million in DDP funds have gone to 42 defense contractors (56 projects) to boost competitiveness in commercial and military markets. Forty additional firms are in the qualification process. For upgrading worker skills, the state gave $1.5 million to 50 firms and has also assisted scores of others in penetrating global markets and in accessing technical resources and government procurement opportunities.

One company, Satellite Transmission Systems Inc. (STS), Hauppauge, N.Y., with over 500 employees, faces formidable competition from Japan and France for ground station terminals. A state grant of $90 000 helps to control inventory for the firm's 18 000 parts. Suppliers were asked to deliver to a fixed production schedule and at lower cost. Good suppliers were guaranteed 80 percent of the business and offered help in improving their own quality levels. STS found that it now spends one-third less on warranty repairs, and sales have increased from $135 000 to more than $200 000 per employee.

Another company, ILC Data Device Corp., Bohemia, N.Y., employs 685 people making data converters, solid-state power controllers, and other devices for military and commercial markets. It received two state grants; one for $33 000 for quality improvement and job-specific skills improvement and the other for $21 000 to develop a strategic plan that would help the company expand into commercial markets. A $10 000 grant was awarded to a company of 55 employees making radar devices, Sensis Corp., DeWitt, N.Y. Sensis will use the funding to create a completely revised marketing strategy. The intended result is an additional $5 million in revenue for Sensis and the creation of up to 30 new jobs within five years.

In March, Governor Cuomo called on Congress to help the states by creating block grants for conversions that utilize existing offices in local infrastructures, like state extension offices, to allow them to react before layoffs occur.

St. Louis metropolitan area. In 1989, nearly one in seven jobs here depended on defense spending. Since then, with the creation of a wide-ranging task force for diversification, several Federal grants have been awarded for job training and planning. A survey of 152 prime contractors in the area, mostly small manufacturers, indicated diversification was already well on its way. Most evidenced a strong desire to expand U.S. commercial markets and introduce new commercial products. One-third, however, noted they would be likely to downsize their St. Louis operations with defense cuts, resulting in the loss of highly paid jobs. Of 18 types of business assistance, firms said they wanted U.S. market research; marketing strategies and techniques; access to financial assistance; quality control improvement; and export aid.

> States would like more Federal money with fewer strings so they can push conversion faster

Of 70 sectors, the task force identified five sectors with the most potential for the area: health services, retailing, air transportation services, business services, and transportation equipment manufacturing. Recommendations included forming a biomedical incubator with local universities, creating a technology transfer program, and starting a regional financing information clearinghouse.

California. California, a bastion of the aerospace industry, gets more defense money than either Germany, England, or France, receiving $43.7 billion in 1991. According to an April report, "California's Jobs and Future," published by the Council on California Competitiveness, San Diego, chaired by Peter V. Ueberroth, the aerospace industry employs 485 000 Californians directly and 730 000 indirectly.

Other reports note that a preeminent U.S. aerospace and defense industry is a sharp advantage over Japan and Germany and should result in spinoffs of innovation in other areas. "For decades these industries have learned to optimize electromechanical systems that are energy efficient, lightweight and highly reliable," says one report. Potential exists for electric vehicles, fuel cells, and other environmental technology. For instance, four firms with aerospace backgrounds have 80 percent of the $7 billion airbag and sensor market for automobiles.

With much of the aerospace industry centered around Los Angeles, an increasingly smog-filled, congested metropolis, the incentive for inventing energy power products and modes of efficient transportation should grow. The Federal Transit Administration has already selected Northrop, TRW, Hughes Aircraft, and Lockheed to compete for work to design a lightweight, clean-air bus prototype for $27 million. Hughes and Lockheed are also teamed up to develop a high-tech train for Los Angeles County.

Members of California's aerospace industry, as well as area utilities, universities, small high-tech firms, transit agencies, and labor representatives, have formed a consortium, Calstart in Burbank, to commercialize aerospace technologies in general and to develop an electric car in particular ["Electric vehicles," *IEEE Spectrum*, November, p. 18].

—*J.A.A.*

The author is grateful to the California Institute for Federal Policy Research, Washington, D.C., for access to its files on conversion.

somewhere other than the American people." Many defense companies, he added, say they cannot borrow money. Then people fail to make the connection between the size of the deficit and the lack of capital. (Yearly interest payments on the U.S. national debt now surpass annual expenditures for U.S. defense.)

When Government intervenes, as it does in job training, for example, the key question becomes "retraining for what?" said Berteau. "What's the job at the end?" The best guarantor of success, he said, is a company that offers retraining. Next best is initiative on an individual's part.

But if the Government is advocating retraining, it's "unclear whether there will be a job" after completion, Berteau said. "We don't even know the time it takes to retrain." Are, for example, the typical Government-aided four-month training courses long enough to retrain engineers? Congress' Office of Technology Assessment (OTA), Washington, D.C., doubts it. [See "Learning new skills," pp. 58–61.]

ARGUMENT FOR HELP. One argument for Federal intervention contends that the support is similar to that of an insurance policy against disasters: it can help prevent a snowballing decline. Localities themselves often are hard strapped.

For instance, an extrapolation done by the University of California, Los Angeles (UCLA), showed that if aerospace layoffs continue through 1995 at 1990–91 rates, the negative impact by 2001 will include 184 000 fewer jobs in all sectors of Los Angeles County. These job losses will boost unemployment costs by $362 million and welfare by $147 million over the decade. Cumulative losses to personal income and retail sales will be $86 billion and $23 billion, respectively. Local government would collect $2.2 billion less in property and sales taxes. The ripple effect of the weaker economy would continue with 122 000 fewer houses being built and $6.3 billion less being spent on construction.

"Every $8 in lost defense revenue will cause a $28 loss in the county's economy as well as a $1 increase in costs and lost revenue for state and local government," said David Hensley and Daniel Flaming in a 323-page report released in March by the Los Angeles-based Economic Roundtable, "Los Angeles County Economic Adjustment Strategy."

Those who argue for special treatment for aerospace workers note that the defense industry served its creator and key customer, the U.S. government. It therefore should not be cast too quickly into free market competition now that the Cold War has ended. More critical is the defense industry's disproportionately large share of engineers and scientists. "It is in the national interest to integrate these workers into the civilian sector as quickly and fully as possible," concluded a February 1992 OTA report. The allure is that a small investment might create a big payoff in such areas as electric vehicles, fuel cells, and smart highways. [See "Some state and local initiatives," p. 47.]

CONGRESS REACTS. In October, Congress passed bills that targeted more than $1 billion for a mix of conversion initiatives. A large part of the allocation went to job training and education programs, including up to $5000 for each military and defense industry worker who wished to prepare for teacher certification. The authorization act creates a DOD Office of Technology Transition and expands the role of the department's Office of Economic Adjustment. It also creates demonstration projects to study the effectiveness of assistance in such realms as national laboratory adjustment, military base closures, and major contract terminations.

Perhaps the most unusual aspect of the bills is the department's economic assistance to industry contractors, who had been "largely ignored" previously, according to Carol Lessure of the private, nonpartisan Defense Budget Project, Washington, D.C.

More than $500 million is slated for this area, according to an analysis by Lessure, much of it to facilitate development of critical dual-use technologies (those with both military and civilian applications) through the Pentagon's Defense Advanced Research Projects Agency (Darpa) in Arlington, Va., and through Federally funded laboratories and regional technology programs. The importance of manufacturing R&D and support for small business research was also highlighted.

But the effort falls short of an integrated plan that many feel is needed to ensure an efficient transition, one that can strengthen competitiveness and leave a capable defense production capability. One critic, Mark Forman, defense economist for Congress' Joint Economic Committee, told an IEEE–United States Activities conference in September, "What we're lacking today is reflective, innovative programs." He conceded part of the problem was Congress, whose No. 1 concern is: "How will this help my district?"

PENTAGON PERSPECTIVES. For defense procurers, conversion presents challenges to maintaining high-quality military capability. There are two basic approaches, one of which meshes with Congress' dual-use theme. The easier, more expensive route, according to Gansler and others, is to maintain an isolated defense capability with a few specialized contractors and Government laboratories and arsenals, at Government expense. This is basically how the defense capability of the United States was maintained in the years before World War II.

1. U.S. allies' defense technology and industrial bases in 1992

Country	Defense budget: In billions of U.S. dollars	Defense budget: As percent of GNP	Number employed in industry	National plan	Civil-military integration	Consolidation strategies
Canada	10.6	1.8%	80 000	Continued close cooperation with United States, limited Govt. intervention, increased Govt./industry consultation	More recognition of dual-use technologies, closer ties between defense and civil R&D organizations	Relying on market forces, foreign demand
France	35.5	3.3%	260 000	Maintain areas of excellence in French defense industry, stress international sales	Govt. encourages diversification of firms, no barriers to civil-military integration	Govt. promoting some consolidation, cross-border mergers
Germany	40.2	2.5%	265 000	Free-market orientation, tight exchange of information between Govt. and industry	Stressing civilian products where militarily acceptable	Industry is down-sizing, Govt. currently not restructuring base further
Japan	34.2	0.9%	N.A.	Limited defense planning, stress on U.S. relationship, use of dual-use technology	Much integration; most defense firms produce civilian products, but a few produce most defense items	Ostensibly left as a corporate decision, but most industrial-sector decisions involve Govt. administrative guidance
United Kingdom	43.1	4.0%	300 000	Reliance on the private sector, greater civilian-military integration, limited Govt. intervention	Relaxed requirements to permit use of civil technology, most defense firms diversified into civil sector	Relying on market forces, Govt. provides information to industry about future defense plans and intentions

N.A. = not available
Source: "Building Future Security," Office of Technology Assessment, June 1992 (adapted)

Military technology searches for contraband drugs

The U.S. government has made its war on drugs the target of converted military technology. The civilian-cum-military work is directed by the Counterdrug Technology Assessment Center (CTAC), which Congress established in 1990 as part of the Office of National Drug Control policy in the President's Executive Office.

The center collaborates with Federal law enforcement agencies in determining what they need in scientific and technological terms to control drug trafficking; then it tries to meet those needs from military developments.

A good example is treaty verification technologies developed for the Strategic Arms Limitation Treaty (SALT). The center is now working with the agency responsible, the Department of Defense (DOD), to apply those technologies to automating the inspection of cargo containers for illicit drugs and contraband. "We're an excellent example of technology transfer," *IEEE Spectrum* was told by Albert Brandenstein, the director of CTAC, Washington, D.C.

TECHNOLOGY TRIO. Brandenstein's responsibilities include converting a trio of military-related technologies to quasi-military uses. They comprise nonintrusive inspection, wide-area surveillance, and tactical equipment for small-unit field operations.

For SALT verification, X-ray systems were used to penetrate and inspect missile warheads, and radiation detection systems to determine quantities of nuclear material. Now the X-ray systems will examine the cargo containers of sea-going vessels, land conveyances, and airplanes for contraband like cocaine and heroin.

The same drugs are also to be detected by radiation-based units, designed to flag the nitrogen found in explosives. "We're now looking for the carbon and oxygen ratios characteristic of heroin, cocaine, and cocaine packaged with hydrogen chloride as a paste," Brandenstein explained. Gamma rays generated by the unit bombard a suspicious parcel, which, in turn, produces the same sort of frequency output as a spectrograph.

In addition, pulsed fast-neutron analyzer systems are being developed to transmit beams of neutrons into containers to identify whether cocaine or heroin is present. Another effort is developing "tags" that a field agent in another country might slip into a suspect cargo container. When the container reached port in the United States, the tag's presence would alert customs inspectors to the situation.

Desert Storm contributes tools used by chemical warfare detection teams in the campaign on the Arabian peninsula. These are small, handheld sensors for collecting samples of solid or liquid materials by wiping them across the surface of, say, a cargo container. The sample is then taken to a gas chromatograph or ion mass spectrograph to be checked for evidence of contraband substances.

CTAC will also investigate the usefulness of wide-area surveillance radar technologies for scanning the ocean or border-crossing points and for penetrating jungle canopy. Other surveillance possibilities are cameras, sensor systems, and remotely piloted vehicles. Being considered as well are the needs of field operations, for which small units of investigators require small radios and small detectors that can look for tags.

The budget of the national counterdrug enforcement R&D program runs to approximately US $150 million yearly, with about $50 million earmarked for each area. The funds are apportioned among Federal laboratories, academia, and the private sector. The sum, while not large, has been leveraged from vast earlier investments, Brandenstein pointed out. "During the Cold War, the DOE [Department of Energy] and DOD easily invested $1 billion for treaty verification technology, including applications of nuclear physics–based technology for nondestructive assay," he said.

> Equipment used to look for nitrogen in explosives can target carbon and oxygen in heroin and cocaine

TACOMA TESTBED. The first testbed for nonintrusive inspection technology will be in place by the end of this fiscal year in the port of Tacoma, Wash. It will include a container-size X-ray machine and a pulsed fast-neutron analyzer. The first automated system for cargo container inspection will be fully tested by the end of 1994, according to Brandenstein. Systems could then be put in place to inspect unopened cargo containers arriving by sea, land, or air.

"Eight and a half million cargo containers cross the U.S. border each year, and we inspect probably 2–3 percent," said Brandenstein. "The Customs Service inspects cargo primarily manually, with limited access to modern inspection equipment."

The United States has 300 border-crossing points and 30 major ports. An X-ray machine at busier points would speed inspections—and hence raise the number of containers inspected—enormously. At a cost of $8 million to $12 million each, and with inquiries already coming in from other countries, Brandenstein sees a market potential of $1.5 billion to $2.5 billion between 1996 and 2000. "We could be launching a new industry," he said. Novel financing arrangements have been considered for the Government to recover the nonrecurring engineering costs.

PINPOINTING SUSPECTS. The counterdrug center's director noted that much more is involved than building a machine large enough to X-ray a 12.5-meter-long cargo container. "We're taking a systems approach to the inspection problem, starting from when we get a manifest on a disk," he said.

Then comes the artificial intelligence processing of information like the shipper's name, address, cargo destination, and loading and transhipment points. From this input and histories stored in a database, associations can be derived that pinpoint suspicious containers. (Something like this has been done for the past two years or so by the Customs Service, and has been shown to improve the probability of choosing the right containers to inspect.)

Brandenstein is also funding a major software development for determining the electronic signatures of a normal cargo and of contraband. Then it would be possible to tell whether cocaine (the target signature) is lurking amid, say, bananas (the clutter).

Pulsed fast-neutron analyzers when used for the quality control of, say, a product's purity have no clutter problem. "Now we have a totally uncontrolled environment," said Brandenstein.

What's more, the drug signatures are modified and possibly made less detectable by what happens along the route a shipment may take. "We must characterize cocaine and heroin signatures under the temperature, pressure, and humidity conditions a shipment encounters in transit."

This effort will benefit from similar work done to develop algorithms for military problems. "We're not creating any new science—we're transferring it from one domain to another," Brandenstein said.

—Alfred Rosenblatt

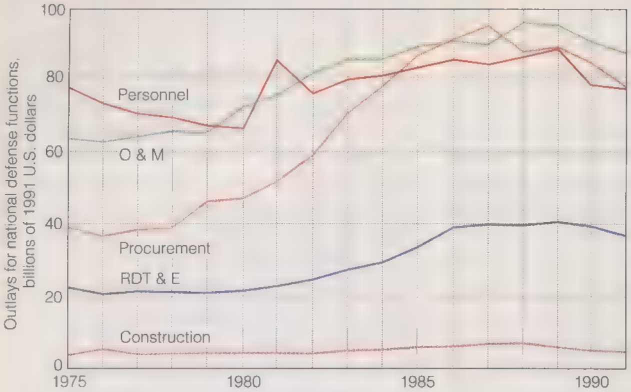
The other approach, being pursued in a number of other countries [Table 1], is to integrate much of the defense technology base with the commercial economy in compatible areas such as electronic components, flat-panel displays, satellites, computing, advanced materials, and telecommunications. Only specifically military developments such as nuclear weapons and stealth technology would be maintained in isolation.

The OTA has reported that the U.S. defense industrial base is increasingly isolated from the civilian one. It says that the current U.S. system may combine the worst of both worlds: the Government lacks the control and protection of an arsenal system but does not get the innovation and flexibility that are potentially available from private industry.

A conversion to tap the commercial base would be more efficient in the long run, Gansler said, and it may also have a salutary effect on U.S. competitiveness. Barriers are many, and include inflexible military specifications and a culture that promotes performance without regard to cost. There are some indications, however, that the Pentagon wants to change.

The post–Cold War lesson, accentuated by the Persian Gulf War, is that the high-technology advantage is critical. In terms of supplies, consumables like ammunition and missiles may be needed within a short period. But such platforms as tanks and planes are not. These can be made at a planned efficient pace, once upgrades no longer suf-

Outlays for national defense functions, 1975–91



RDT & E = research, development, test, and evaluation;
O & M = operations and maintenance.

Source: Office of Management and Budget

Funds for defense procurement rose especially sharply during the 1980s and can be expected to fall sharply in the 1990s. Many authorities say that R&D will gain a bigger portion of the defense budget but will also shrink in real terms.

fice and new models become necessary.

Torelli, the Pentagon's deputy assistant secretary of defense for production resources, is trying to identify unique, essential capabilities within the U.S. industrial base to determine when to shut down military production lines and how fast they could be restarted. The goal is to inject some rationale into a debate often dominated by emotion and special interests, to the delight of lobbyists. With dwindling defense budgets, the Pentagon has more incentive to halt production stretchouts.

Torelli's group has examined tank production and has turned its attention to submarines. Because of the large inventory of tanks, national security would not be affected if the line were to be closed, he said. Moreover, if ■ few critical items were stockpiled, and a list of uniquely skilled labor was kept, restart time could be cut by a year. (A large tank deal to Kuwait recently made this question moot for years.) Although production could be completely shut down, R&D on tank armor, sensors, guns, and propulsion should be continued, however. A breakthrough in light armor, Torelli said, could obsolete the 60-ton tank.

To tie in more closely with the civilian economy, Torelli, a former nuclear submarine crew member and industry production manager, is trying to reduce the number of military specifications and standards "as fast as we can." A February 1992 report by the Business Executives for National Security, Washington, D.C., said that some 20 000 of 34 000 military specs and standards are for products and processes that could be replaced by commercial ones. Already, however, since 1989 about 5000 military specs have been eliminated or replaced by commercial ones, Torelli said. More general performance specs are being used "wherever possible" to attract the most qualified bidders, he added.

Tapping into the commercial base would mean that instead of maintaining a separate defense line for a "war stopper" item like butyl rubber gloves (as protection in chemical warfare), the line would be integrated into commercial lines having the same process technology.

"We expect and encourage downsizing to happen," said Torelli. "Do we need six airframe manufacturers out there? No. How many? I don't know, but more than one." Consolidation in missile production has already begun with Hughes Aircraft Co. purchasing General Dynamics Corp.'s missile operations in San Diego. Now there will be a robust manufacturer with the incentive to make capital improvements.

Although procurement reform has been an ongoing issue, the defense budget shrinkage provides an incentive for real reform: if the Pentagon cannot make working in defense easier, it risks losing the best-qualified contractors and missing out on the low-cost, high-quality expertise in the civilian sector.

"We have been pushing, nagging DOD to change" its ways of doing business, said Robert White, under secretary of technology at the Department of Commerce. White recalled that in his prior job at Control Data Corp., the company (like many others) maintained ■ separate building and accounting operation for its defense work.

Some changes at DOD already in the works should help to integrate civilian and military development. Eleanor R. Spector, the Pentagon's director of defense procurement, outlined several for *Spectrum*:

- A panel is reviewing a broad range of statutory requirements so as to streamline the acquisition process. Its report is due to the under secretary of defense for acquisition by Dec. 15.
- Simplified rules, published as an interim rule in the *Federal Register* on April 23, 1991, have reduced many burdens of the commercial supplier by prohibiting in-plant inspection by the Government, and the use of military specifications or standards to impede the purchase of ■ commercial item. The rules also limit the acquisition of technical data rights, as well as cost and pricing data, and they cut down on the amount of proprietary information commercial companies must share with the Government.
- A Government/industry/academia committee has "reached some tentative agreements that will increase the protection of contractor rights in data." The group's recommendations are expected to be completed in January.

MORE CHANGES NEEDED. The OTA, drawing on ■ wide variety of authorities in and out of the Government, has put out a series of reports over the last two years on defense restructuring. Rather than the usual menu of options, these OTA reports are unusual-

Japan: converting military defeat

When World War II ended in August 1945, Japan's industry lay in rubble. For years after the country's defeat, the Allied Occupation Forces General Headquarters (GHQ) forbade the country any manufacturing that could remotely be construed as ■ military threat. The Japanese Government itself was too disorganized and demoralized to help industry reorganize from its overwhelmingly military production during prewar and war years to design, develop, and manufacture civilian and commercial products.

Yet the country did indeed convert from a military economy to a civilian/commercial economy, a conversion based largely on technology. In the process, the nation became an economic superpower.

How that economic miracle came about has recently been addressed by a group of Japanese historians, engineers, and scientists who lived through and participated in the transition. Calling themselves the Working Group of the Committee of High Technology and International Environment, they have held hearings since early this year. So far, six engineers have recounted their conversion experiences and offered insight into why it worked so well. The hearings continue, and the group plans to compile the testimony into a book, to be published first in Japanese and later in English. The Japan Society for the Promotion of Science sponsors the Working Group.

Several members of the group shared their experience with *IEEE Spectrum*. They recalled the devastation and hardship people lived through, the spirit of cooperation among those who could work, and the innovative ways in which wartime technology was adapted to peaceful purposes. Michiyuki Uenohara, now executive advisor to NEC Corp., Kanagawa, remembered that, at one point, most Japanese who were in military service were prepared to receive the death penalty from the victors. When this fear proved groundless, they gladly accepted any hardship in order to survive. All of them—researchers, design engineers, manufacturing engineers, and factory workers—worked together to earn their living. This cooperative spirit is in marked contrast, Uenohara believes, to attitudes prevailing in the struggling countries formerly behind the Iron Curtain and even in the shrinking U.S. defense industry.

Jun-ichi Baba, now board advisor to Mitsubishi Electric Co., cited the Japanese people's high regard for crafts and technologies, their commitment to hard work, and "outstanding leadership on how industrial technologies should be developed" as major factors in the country's resurgence. But help

ly direct, and indicate that much more change is needed in post-Cold War conversion efforts.

Nothing less than a "shift in thinking about what constitutes national security and the role of science and industry in maintaining it" is needed, according to "Building Future Security" of June 1992.

Advanced technology is still critical and should be extended beyond the narrow focus during the Cold War on enhancing battlefield performance. What's needed is a broader approach that takes into account defense manufacturing, maintenance issues, and economic security, according to the OTA.

New allocations of resources among three main elements—R&D, production, and maintenance—is required. Many engineers may take heart that the "Redesigning Defense" OTA report of July 1991 states that the R&D component of the defense technology base "must receive first priority."

In addition, a revamped defense procurement structure must be willing "to purchase knowledge rather than hardware in many cases."

One approach to preserving key defense-related design and manufacturing teams, and spurring innovation, is called prototyping plus. It would involve continuous development of prototypes and, in some cases, limited produdtion for operational and field testing. Greater reliance on prototyping (rather

into commercial victory

from a former enemy, in the form of food and technology from the United States, was a factor, too, he believes.

Shigeru Nakajima, now retired, was an engineer at Japan Radio Co. during the war, producing communications equipment, radars, and vacuum tubes for the Army and Navy. (He later rose to become senior managing director at Japan Radio and president of Aloka Co.) When the war ended, Japan Radio terminated almost all of its 50 000 employees, then rehired 800 a few months later when GHQ permitted the manufacture of receivers, vacuum tubes, electric heaters, and medical equipment—but not the manufacture of transmitters.

Obtaining materials for production was extremely difficult, Nakajima recalled, and much of what the company finally turned out was of poor quality. With product yield low, it was hard to turn a profit—and to pay employees. Japan Radio finally succeeded in getting permission to build transmitters—albeit low-power ones (1 kW or less)—in 1946. Nakajima believed his company could not have survived without a transmitter product line.

Engineers who had served in the military or worked in defense industries adroitly turned their wartime skills to advantage. Aeronautical engineers moved to the automobile industry, optical engineers changed from bomb sights to cameras, and radar and cathode-ray tube engineers concentrated on consumer electronic products.

Examples of such technology transfer abound. Nakajima told *Spectrum* a story he often heard from naval officers during World War II. They recounted that often "when we think we have discovered with our ultrasonic detector what looks like a hostile submarine and have trailed it for a while, we lose sight of it. Maybe we sometimes mistake a school of fish for a submarine."

After the war, eager to diversify Japan Radio's limited civilian products, Nakajima proved that ultrasonic beams can locate schools of fish. He eventually got permission to build fish detectors based on antisubmarine sonar—and found he had a runaway domestic market. Fishing fleets were soon boosting their catches with electronic help, to the relief of a nation desperately short of food.

Fish detector technology eventually yielded other benefits. Nakajima recalled that two physician-professors from Juntendo University called on him, unannounced, in the autumn of 1950. "They wanted to buy one fish detector. I thought that these doctors must love fishing," Nakajima told us. As the men talked, it became clear to Nakajima that they wanted to detect cancer inside the human body "with a fish finder." The engineer politely explained that his equipment could not identify changes in tissue only a few millimeters away from the ultrasonic source.

But the doctors' idea fired Nakajima's imagination, and he began developing ultrasonic products for medicine. Acceptance was slow, however, until professional midwives heard of it in 1955 and recognized ultrasonics' safety and effectiveness in determining fetal health. After that, "tens of thousands of these units sold instantly," Nakajima said.

Interestingly, engineers used to military work ran into many of the same problems their U.S. counterparts now do when they turn to civilian work. Sogo Okamura, now president of Tokyo Denki University, told us about an engineer friend who, after working on Army and Navy electronic equipment, set up a factory to make electron tubes for commercial receivers. The friend believed that producing tubes for radios would be simple compared to making sophisticated tubes for military use. But his commercial customers found the tubes unsatisfactory, and even though the factory quickly improved the products' quality, it took eight to 10 years to get back in the customers' good graces. For successful conversion, the friend told Okamura, "it is necessary to change the attitude of managers, engineers, workers, and salesmen."

> The spirit of cooperation in postwar Japan was greater than it is anywhere today

The need to standardize was a lesson learned in Masahiko Fuketa's transition to commercial products. Since prewar days, Fuketa's company had manufactured photographic lenses for military aerial cameras. Management recognized high-quality, precision-built 35-mm cameras as a promising civilian product and began to manufacture them after the war—with a difference: to make their cameras as compact as possible and to get the most from a roll of film, the company decided to reduce the frame width to 32 mm; that made it possible to take four or five more photographs on a 36-exposure roll.

The company started marketing the cameras in April 1948, with resounding success. They sold well not only in the domestic market, but also in the post exchanges of the U.S. Occupation Forces. But success was short-lived; when customers had their film developed in the United States, they found that automated equipment cut pictures according to the traditional size; they wound up with parts of different photos on the same print. "It ballooned into an issue of such serious dimensions that a prohibition was put into effect on the manufacture of odd-sized merchandise," Fuketa told us.

The company—the now-famous Nikon Corp.—survived the incident and eventually flourished. But for would-be converters, Fuketa had this advice: "This is the case history of a failure resulting from an arbitrary writing of specifications by a company that was used to dealing mostly in made-to-order products. From this bitter experience, we realized the necessity of extensive and thorough research of the market, in order to go into the free civilian field."

The tide turned fully for Japan in the 1950s. During that decade, GHQ gradually relinquished its authority and the Ministry of International Trade and Industry (MITI) began to shape the country's business environment, often licensing foreign technology to bolster indigenous efforts. (MITI is now a model organization for many rising Asian nations.) Japan grew steadily to its present eminence as a producer of high-technology products.

Government support like that offered by MITI and other Japanese agencies was a critical element in the country's conversion, many Working Group members believe. "It is necessary for a nation to foster venture capital," Shigeru Nakajima told *Spectrum*. "A view that tax money should not be used to help a private company or an individual is essentially wrong." —*G.F.W.*

Spectrum is indebted to the following people for information on Japanese postwar conversion: Jun-ichi Baba, Mitsubishi Electric Corp.; Masahiko Fuketa, Nikon Corp., retired; Ken-ichi Inada, chairman, Working Group of the Committee of High Technology and International Environment, Japan Society for the Promotion of Sciences; Hiroshi Inose [F], National Center for Science Information Systems; Kihachiro Matsuyama, Japan Broadcasting Corp., retired; Ryoichi Nakagawa, Nissan Research Center; Shigeru Nakajima, Japan Radio Co. and Aloka Co., retired; Sogo Okamura [LF], Tokyo Denki University; and Michiyuki Uenohara [LF], NEC Corp.

2. Defense-related jobs in U.S. manufacturing industries, 1990

Industry	Defense employment in United States[a]	DOD-dependent jobs as percent of industry total[b]
Radio and TV communication equipment	194 000	46%
Aircraft	163 000	44%
Shipbuilding and repairing	128 000	98%
Guided missiles	120 000	90%
Aircraft parts and equipment	86 000	49%
Aircraft engines	64 000	43%
Ammunition, excluding small arms	29 000	77%
Other ordnance and accessories	16 000	68%
Tanks and tank components	11 000	75%

a All U.S. manufacturing jobs total 3 150 000.
b All other defense jobs depended on non-U.S. military purchases. For example, 75 percent of jobs in the manufacture of tanks and tank components depended on Department of Defense (DOD) purchases, the rest on non-U.S. military purchases.
Source: Office of Technology Assessment

than production) would advance systems technology and support deployment of the most advanced equipment, but it would sacrifice large manufacturing teams. Yet limited prototype production could reduce the "boom-and-bust development cycle of the Cold War era with a more deliberate process," said the OTA. The hope is that the prototyping-plus approach could be structured to preserve the full range of critical design, manufacturing, and support skills.

The elements, from research to maintenance, should be better integrated, which may also require reorganizing DOD and Congress. The Government should not intend to proportionately shrink the defense base, but rather maintain unique skills. For instance, unlike submarine production and munitions design, electronics skills can be maintained in the civilian base "with little government intervention," according to the June OTA report.

U.S. commercial manufacturing companies, however, "will be hard put to take the place of defense industries," which are heavily tilted toward high-paying manufacturing jobs, warned a February 1992 OTA report. Overall, the two sectors need to be better integrated, according to the OTA, for reasons of cost, total capacity, and potential for innovation.

BOOSTING COMPETITIVENESS. As Berteau noted, a rising economy would solve the defense conversion problem. While Gansler warned that the Defense Department "will not solve U.S. competitiveness problems," he pointed out that making better use of its $35 billion annual R&D budget could help.

The DOD's continuing investment in R&D dwarfs by an order of magnitude most other Government programs for precompetitive generic civilian technology assistance and development. Such programs include the state technology extension programs (never exceeding $1.3 million annually) of the Commerce Department's National Institute of Standards and Technology in Gaithersburg, Md., as well as the institute's advanced technology program (funded in 1992 at $47 million).

> The U.S. government lacks a conversion strategy, though tossing billions at discrete programs

One area that is expected to gain more Federal priority is manufacturing. This process technology can ripple through the entire economy, said Commerce's White, observing that even low-tech products are often made by high-tech processes.

In the commercial world, White noted, manufacturing is being driven by marketing; soon many products will not be made until they are ordered, which jibes nicely with defense goals. The United States, he added, should become a leader in lean, agile manufacturing because of the country's preeminence in computers and communications.

The Commerce under secretary also envisions a national manufacturing network of hundreds of nodes. He noted that a special initiative is being planned across Government agencies, including DOD. Such interchanges might also benefit collaboration between companies.

"Defense Science and Technology Strategy," a July 1992 report by Victor Reis, director of the Pentagon's Defense Research and Engineering, shows how the United States hopes to create "an economical yet technologically superior force." Among its seven priorities is "technology for affordability," which could have some important implications in the conversion and realm.

Many observers like Gansler state that the Pentagon emphasizes product development to the detriment of process development. The result is expensive products with long procurement times. Reis's report estimates that manufacturing functions like production control and inventory management account for more than 60 percent of the cost of a complex military product.

Michael F. McGrath, a program manager at Darpa, is overseeing the technology affordability thrust. He told *Spectrum* recently that "worrying about affordability early on in science and technology programs represents a cultural change" in the defense business.

In this respect, the thrust could move defense more toward commercial concerns. McGrath is looking for generic process technologies. "We'll attract companies with both commercial and defense interests," he predicted. For instance, one existing Darpa program with Texas Instruments Inc., Dallas, and Stanford University in California might lessen the need for expensive semiconductor clean rooms by transferring wafers between stations in portable evacuated containers.

McGrath hopes for production lines agile enough to switch from one product to another, commercial or military. A "virtual factory" concept involves debugging the simulation of an entire production process of a new unit before transferring the software to a real factory. Such capability is especially important for small lot production where, he said, "you can't afford 15 or 20 mistakes; you want the first one to come out right."

This is being done today on application-specific ICs, McGrath acknowledged, but the Defense Department has begun trials funding components and subsystems further up the hierarchy, such as infrared sensors with associated electronics and cryogenic cooling; multichip modules; and signal processors.

Although integrating design and manufacturing may cost more up front, it may be 10 times cheaper than trying to fix problems in engineering or 100 times cheaper than fixing problems in production. "You're not wrestling with process issues when the clock is running and there are thousands of people on the payroll," he said.

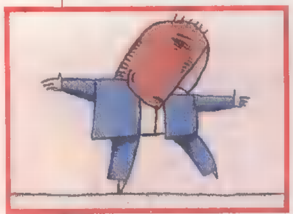
To reduce manufacturing overhead costs, the DOD is examining advanced information technology. This notion of "industry command, control, and communications" is similar to that on the battlefield, McGrath observed—diverse units in need of timely coordination—so it could be a potential spinoff. Protocols and standards are being worked out with Commerce.

By McGrath's initial estimate, only 5 or 6 percent of the Pentagon's science and technology base budget is devoted to process technology, a ratio that analyst Gansler scorns as being much too low. Yet that budget share can be expected to grow as programs are implemented.

Such swift response and flexible manufacturing capability could be a spinoff in itself and a boon to commercial industry. If that capability is actually implemented, it could resemble the interchangeability of the village blacksmith who could easily switch between spears and pruning hooks. ◆

DOE labs: models for tech transfer

Department of Energy laboratories join with companies in projects that could set the pattern for other government labs



Amid continuing controversy over their post-Cold War role, the U.S. national laboratories are busy re-inventing themselves. Their new mission: helping to maintain U.S. security *and* its competitiveness in the world market.

Perhaps farthest along are the laboratories administered by the Department of Energy (DOE), particularly those involved in weapons work: in California, the Lawrence Livermore National Laboratory; in Tennessee, Oak Ridge; and in New Mexico, Los Alamos and Sandia. Weapons R&D will remain a large part of their charter; in addition, they are developing strategies to implement their new R&D mission.

At stake is an annual budget of US $6 billion, which dwarves the R&D budgets of all the military services put together. The funding supports the activities of a technical staff of about 29 000, making these labs ''the crown jewels of the U.S. R&D establishment,'' to quote one technology transfer consultant, John Trudel, president of the Trudel Group in Scappoose, Ore.

But laboratory officials responsible for technology transfer do not see their primary mission as doing applied research for new products, nor as developing products themselves on the basis of military technology.

''Our new role is not turning swords into plowshares,'' said Ted Dellin, director of the Microelectronics Quality/Reliability Center at Sandia National Laboratories in Albuquerque. ''Rather, it is to provide the tools to build both plowshares and swords.''

In the past, the labs have had, as a subordinate goal, conversion of their defense-oriented output, where possible, to peaceful applications in the commercial sector. ''What has changed is the emphasis,'' said Dan Arvizu, director of Sandia's technology transfer program. Dual use is now the key. ''We're after the R&D of technologies and the development of expertise and services that support both commercial and military applications.''

Bernard Cole Contributing Editor

This concept turns the entire process on its head, in that the needs of U.S. companies in the marketplace become the prime motivator, said Robert McCormack of *New Technology Week*, which covers activity in technology transfer. ''This does not mean that defense needs become secondary,'' continued the newsletter's editor in chief. ''It means that the needs of the two are often the same.''

Why the change in attitude? According to John Umbarger of Los Alamos National Laboratory, the Federal laboratory establishment has realized that the private sector is ahead in many areas critical to defense readiness. This is especially so in electronics and semiconductors, said Umbarger, deputy director of the lab's industrial patent center.

The implication is that the labs should avoid developing anything supplied more economically by industry and instead develop core capabilities that will enable industry to build better products, said Sandia's Dellin. ''At the same time, this would provide our military with the critical technologies they need,'' he added.

> The laboratories' new mission is to provide the tools for producing both plowshares and swords

In this context, the DOE labs have developed the concept of core competencies. Nurtured over the last 20 to 40 years, these competencies include expertise in materials, testing, modeling and simulation, advanced computing hardware, advanced manufacturing, and quality and reliability control, according to Sandia's Arvizu. ''Where each of the laboratories differs is in the technologies it emphasizes to make use of these core competencies,'' said the Sandia executive.

Products have evolved and will evolve out of some of the labs' work, he continued, but they are a side benefit and should not be the labs' focus. ''Just as we have our core competencies, industry has its set also—product development, marketing, and applying the basic research to actual products,'' he said.

Industry is beginning to take note of core competencies and the laboratories' potential as an R&D resource. Over the short term the labs are also viewed as a resource for solving day-to-day testing and manufacturing problems. ''Our work with Los Alamos and Sandia over the past two to four years has had its ups and downs,'' said James Rutledge, director of university-national laboratory programs at Sematech Inc. of Austin, Texas, a consortium of semiconductor and semiconductor equipment manufacturers. ''But they provide expertise and technology that we couldn't get elsewhere.''

This kind of activity has been possible only since 1989, with the passage of the National Competitiveness Technology Transfer Act, an improvement on the 1986 Federal Technology Transfer Act. The law authorized—indeed, directed—the weapons laboratories to actively search out and form alliances with companies. The enabling factor is a new legal mechanism—the cooperative research and development agreement (Crada). Since then, joint activities between the weapons labs and private industry have outpaced the activities of all the other Federal labs, both in numbers of projects and rate of growth, said Debra Wince-Smith, assistant secretary for technology policy at the Department of Commerce.

According to Commerce's just completed report on cooperative R&D efforts in the Federal government, by mid-'91, after a year and a half of national laboratory participation, 52 Cradas had been formed by the DOE laboratories, two-thirds of them with the weapons facilities at Lawrence, Los Alamos, Oak Ridge, and Sandia. All told, 150 or so Cradas have been signed since the year began, or about 85 percent of the cumulative Crada total, said Richard Mullins, assistant secretary for technology policy and technology administration within Commerce. They represent an R&D investment of $300 million to $400 million, more than 60 percent of which comes from nongovernment partners, said Mullins. By year-end, Cradas are estimated to total nearly 300.

The Cradas entered into by the weapons labs are quite varied. Some involve direct

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transfers, granting a company access to critical technology that will result in a new product. Most, though, involve those core competencies: technical expertise and services in key areas. The partners range from small companies entering into pacts with one lab to larger companies that first form cooperative precompetitive consortia and then enter into agreements with one or more labs.

In the small company category are, for example, Radiant Technologies Inc., Albuquerque, and Plasma Physics Corp., Locust Valley, N.Y. In the last nine months, Radiant has entered into two Cradas with two national laboratories and is completing a third agreement with yet another; all are related to ferroelectric nonvolatile technology. Plasma Physics recently acquired the rights to a new transistor fabrication technology developed in China, and has entered into Cradas with two laboratories, one for the use of special proton implanters and the other for testing and analysis of submicrometer circuits.

The consortia category is a virtual who's who of major U.S. corporations who have entered into Cradas involving advanced computing, laser, and manufacturing technology. Companies include AT&T, IBM, LSI Logic, and National Semiconductor.

What enables Cradas to accelerate the transfer of technology from the military sector to the commercial is their flexibility. Broadly defined, said Mullins, a Crada may be any agreement between one or more Federal laboratories and one or more companies that calls for each side to contribute personnel, services, facilities, and equipment on a 50/50 basis toward specific research efforts. Virtually the only limitation on participation is that while the companies can also contribute monies to the project, the Federal labs cannot.

"The broad definition of the Crada is both its strength and its weakness," said McCormack of *New Technology Week*. "As a result, it is in a constant state of evolution. But already it is one of the most promising means" of technology transfer.

CATALYST FOR ACTION. This optimism, he said, is based on the Crada's freedom to combine a variety of mechanisms—patents, pilot projects, consortia, contracting and subcontracting—in a variety of ways. In other words, the Crada legislation defines the elements that must be included, but does not limit or constrain how the parties involved may put these elements together. Of key importance is the Cradas' (legal) circumvention of the red tape of the Federal Acquisition Regulations.

Because the terms of a Crada are flexible, each agreement can be tailored to the needs and resources of the participants. As part of the process, the partners draw up a joint work statement outlining the scope of work, the responsibilities of each organization, schedule, and other specifics. The statement is submitted, separately but in conjunction with the Crada, to the DOE for its approval. The Crada goes to DOE after all partners have signed their names to its terms and conditions ["Guide to co-operative R&D agreements," below].

Since its 1986 and 1989 formalization in the two technology transfer acts, the Crada has evolved into a highly effective instrument. Individuals as well as labs get a break in that a minimum of 15 percent of royalties on Federal patents has to be awarded to Federal inventors. "That has had remarkable effect on laboratory scientists and engineers, convincing them to look for ways to commercialize their technology or find commercial outlets for their expertise and facilities," said McCormack.

On the corporate side, the most significant modifications in the Crada were the 1989 inclusion of mechanisms to speed up the reaching of a cooperative agreement and, more importantly, the exemption of

Cooperative R&D agreements: a guide

The cooperative research and development agreement (Crada) is becoming the preferred method for transferring Government technology to private industry. Cradas were made possible in 1986 by the Federal Technology Transfer Act and extensively modified in 1989 by the National Competitiveness Technology Transfer Act.

Other methods of cooperating with the Government's national laboratories remain in force. Cradas, though, are unique in being free of the many legal conditions placed on, say, contracts, grants, and patent assignments. Most arrangements between Department of Energy (DOE) laboratories and private companies are structured through Cradas, according to Warren Chernock, deputy science and technology advisor in the agency's defense programs division in Washington, D.C.

Entering into a Crada involves six major steps, or rather, two sets of three steps apiece: to start with, a joint work statement is prepared, then reviewed and approved first by the appropriate laboratory organizations and then by the DOE. Next, the agreement between the laboratory and the partner(s) in private industry is prepared, then reviewed and approved by the laboratory and the DOE.

As with any company's research plan, the joint work statement is meant to ensure a common understanding of the aims and scope of the work to be performed, said Chernock, and to speed up the issuance of the actual Crada. "We are trying to make the process similar to contract negotiations between two companies [and] make sure everyone is talking the same language about such things as estimated cost and sources of support, benefits and impact to each party, intellectual property, proprietary information, and liability issues," he said.

If the joint work statement is agreed upon, he said, the Crada can be processed in a matter of weeks, a speed "unheard of in ordinary contract negotiations between companies."

But rough spots do exist, according to James Rutledge, director of university–national laboratory programs at Sematech Inc. in Austin, Texas. He said that members of his consortium of semiconductor and semiconductor production equipment manufacturers feel that the process is redundant: "In essence, companies are asked to go through approvals twice, once for the joint work statement and again for the actual agreement, each time subject to reinterpretation of some of the terms." As a result, he said, a process that should take no more than a few months may drag out much longer.

Another complaint concerns the way in which laboratories approve the joint work statement, in the second step of the approval process. The routing sequence for approval can be quite involved, according to Rutledge. At Sandia National Laboratories, Albuquerque, N.M., for instance, this cycle includes the project manager, that manager's department manager, the administration division, accounting, the overall program manager, and the legal and finance departments. Still, if the project is really of interest to the engineers at the laboratory, they will often help the companies they are negotiating with, said Jeff Bullington, president of Radiation Technologies Inc., also in Albuquerque. "There are always shortcuts and ways to get through the process quickly if both sides are motivated," he said.

In his review of many of the Cradas approved so far, Chernock said he saw no unreasonable delays. Nonetheless, he admitted that the DOE is studying how to speed up the process. For example, where routine participation in a Crada is expected and little or no negotiation is required, there is a generic Crada available that has been pre-approved by the DOE. The department also now allows the work statement and the Crada to be developed and processed through the approval cycle in parallel.

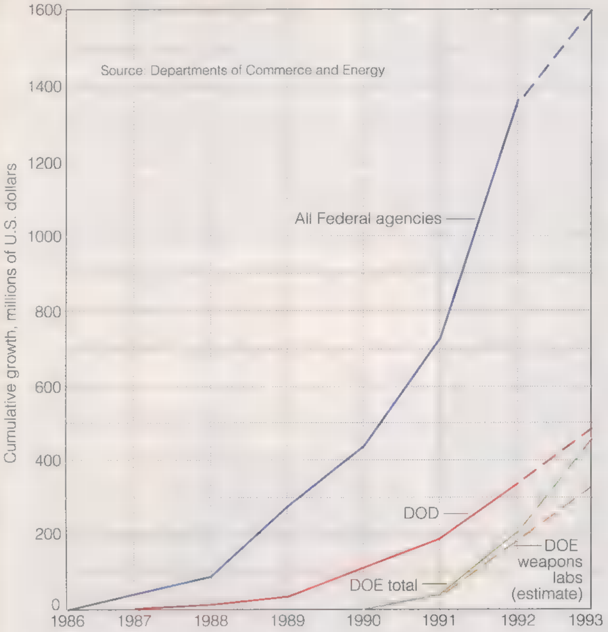
In the works is a set of Crada templates that are applicable to particular industry segments. These templates formalize details of contractual arrangements unique to each. The issue of liability, for instance, matters more to an auto or medical instrumentation maker than to a test instrument or semiconductor manufacturer.

The DOE is also looking at the cost-sharing ratio, currently roughly 50/50. "But we have found situations where different ratios might be appropriate over the life of a Crada," Chernock told *IEEE Spectrum*. For example, in a leading-edge technology where significant basic research is required, it might be appropriate for the laboratory to bear 90 percent, whereas the reverse might be better at later stages of development.

Chernock said that the DOE is also looking at varying the ratios depending on the size of the company, with the laboratory picking up 90 percent of the cost when dealing with a start-up and 50 percent or less when dealing with a large corporation or a consortium of companies.

"Congress has legislated the Crada as the primary technology transfer mechanism," he said. "So it is in our best interest to make it work." —*B.C.*

Cooperative R&D agreements (Cradas)



The number of cooperative R&D agreements (Cradas) with private companies has mushroomed at the weapons laboratories administered by the Department of Energy.

Cradas from Freedom of Information stipulations for up to five years. "Those two improvements did a lot to overcome the reluctance of companies to participate," said Sematech's Rutledge.

By being able to implement an agreement in a matter of weeks, companies can address short-term needs and get help as problems arise in processing, fabrication, and testing. "When you have a problem your own engineers find intractable, you would like to go to the institutions, like Sandia and Los Alamos, with the expertise to come in and quickly diagnose a problem," Rutledge said. "But if it takes months to come to an equitable agreement, by then the problem has been solved or the company has lost its shirt."

Moreover, the protection accorded to jointly developed technology and its five-year proprietary status, sheltered even from a search under the Freedom of Information provisions, lets companies protect their competitive advantage, noted Rutledge.

"Five years is a good compromise," said Sandia's Arvizu. "That gives a company enough of a buffer against the competition, but at the same time gives the Government laboratories the right to pursue commercial applications over the long term."

NO LACK OF CUSTOMERS. According to Umbarger of Los Alamos, industry's response has been staggering. "While some of the enthusiasm is due to the bad economy and reduced R&D investments by companies, the 50/50 arrangement on equipment, facilities, technical services, and personnel otherwise unavailable to them is proving an almost overwhelming lure," he said.

One company that has grabbed at the bait not once but twice and is going back yet again is Radiant Technologies. It was started two years ago by Jeff Bullington and Joe Evans, president and vice president, respectively, and has built up a strong patent position in ferroelectric ceramic thin films for use in ICs. (Bullington and Evans also founded Krysalis Corp., one of the original ferroelectric memory companies, since acquired by National Semiconductor Corp.)

Radiant is using its intellectual property as a "technology incubator and R&D middleman," said Bullington. On the one hand, it has entered into development contracts with some semiconductor and computer firms who want to commercialize the technology. On the other, it has entered into Cradas with national laboratories to gain access to additional technical expertise and hard-to-come-by equipment and modeling capabilities.

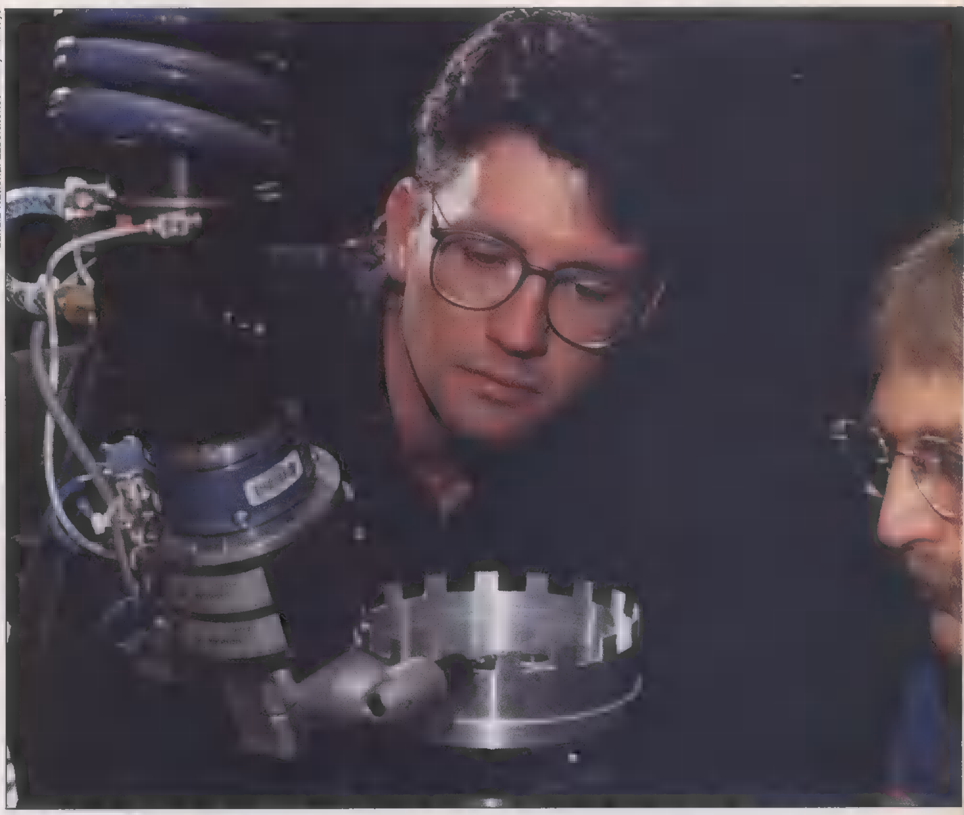
In the initial Crada with Sandia National Laboratories, Radiant will make use of the Federal facility's Advanced Materials Laboratory and its expertise in nonvolatile memory materials and testing. The just approved three-year agreement is worth $3.2 million.

What the lab brings to the table is its experience in thin-film lead zirconate titanate (PZT), which it developed in work on superconducting technology for DOD and more recently for commercial applications. "We aren't interested in the superconductive aspects, but rather in their ability to form thin films with this material," said Bullington. "That expertise, we believe, can be used in a new nonvolatile variable resistive element we have developed, which could have wide applications in not only nonvolatile memories but in [static] RAMs and neural networks as well."

In static memories, he said, there is a need for submicrometer resistive elements in the megohm range; but devices built with today's submicrometer design rules have too much current leakage. Neural networks, to be truly adaptive, must use resistors that can be reprogrammed on the fly. "We believe the devices we have in development will be useful in both areas," Bullington said. At present, either a gate switch plus an array of fixed resistors or electrically erasable programmable ROM is used. Neither is practicable in very large-scale IC form.

Under the Crada with Sandia, Radiant will coordinate the program, design and manufacture prototypes, and help design plasma-enhanced metallorganic deposition

Sandia National Laboratories/Randy Montoya



As they check a robotic deburring system that relies on tactile and optical sensing to do hitherto manual tasks, Cliff Loucks and Colin Selleck of Sandia National Laboratories' Intelligent Machines Division have their eye on commercial applications.

equipment for making the thin-film resistive elements using PZT. Sandia will characterize the thin-film interface and investigate methods for measuring film properties, as well as characterize fatigue mechanisms.

"What surprised us was the speed with which the Crada was approved," said Bullington. "We had heard about the bureaucracy and red tape. For us, the process took six weeks. These guys are serious about working with industry."

That was also about how long it took to negotiate a second $3 million pact with the Los Alamos National Laboratory on another project: the development of a very high-value capacitive material for use in submicrometer capacitors for next-generation ICs. "The current perovskite ceramic materials, based on PZT and barium titanate, are just not adequate," said Bullington.

In the Los Alamos arrangement, Radiant is utilizing the laboratory's knowledge of another type of ferroelectric material, YBCO (yttrium barium copper oxide), for use in high-radiation environments. The company wants to develop thin-film capacitive materials that can store much more charge than present materials.

A third deal is in the making, for the development of an optical-disc technology based on the optical birefringent characteristics of ferroelectric thin-film ceramics. "We have a commitment of $8.5 million from a consortium, and we're looking for a matching $8.5 million in the form of a Crada with Sandia," Bullington said.

A NEW INSULATOR. Stretching the Crada concept in still another way is a company formed by inventor John Coleman. His Plasma Physics Corp. has just entered into two parallel Cradas, one with Brookhaven National Laboratory in Upton, N.Y., under DOE supervision, and the other with the Massachusetts Institute of Technology's Lincoln Laboratory, under Defense Department supervision. The goal is to commercialize a new semiconductor structure called silicon on defect layer (SODL).

The defect layer is created by implanting hydrogen protons in a silicon substrate. The discovery was made by Jianming Li of the Chinese Academy of Sciences' Institute of Semiconductors in Beijing. By arrangement with the Chinese, Coleman has patented the structure in the United States.

"When I read about Li's research, it seemed an enormous improvement over esoteric techniques, like silicon-on-insulator [SOI], that are being considered to achieve higher [static and dynamic] RAM densities," said Coleman. Preliminary studies showed that the structure added fewer steps to the fabrication of a normal complementary MOS memory than do alternatives.

In Li's original test devices, proton implantation formed a high-resistivity layer beneath the silicon substrate surface. It was followed by a two-step annealing procedure, much as in SOI. The implanted protons form many gas bubbles just below the upper silicon surface, and these disturb the crystalline structure. The result is a buried defect layer with a resistivity on the order of 1 kΩ/cm or more, three orders of magnitude greater than for the original bulk silicon.

This higher resistivity, said Coleman, lowers the parasitic capacitances in devices fabricated on the top layer and in this way increases the mobility of electrons by about 25 percent. The work done in China was with 5-cm wafers and 2–3-μm CMOS processing. Over the next year, Coleman said, the plan is to build the devices at Plasma Physics, and do the implantation of the hydrogen at Brookhaven and the testing at Lincoln Laboratory.

X-RAY LITHOGRAPHY. Cradas are also speeding the DOE labs' entry into the lithographies needed for next-generation RAMs. The basis will be X-ray and laser technology developed in fusion bomb research and for the Strategic Defense Initiative.

In one case, Lawrence Livermore National Laboratory has been working with Hampshire Instruments Inc., Rochester, N.Y., contributing its high-power laser expertise to the generation of secondary soft X-radiation. The lab is now in negotiation with a U.S. manufacturer of liquid-crystal displays (LCDs); the goal is to develop equipment for fabricating active-matrix LCDs with sufficient pixel density to serve as displays in high-resolution television receivers.

In another case, Sandia's California facility in Livermore has a Crada with AT&T Co. to develop an instrument that generates X-rays directly for device fabrication.

According to Lloyd Haskel, who directs the X-ray effort at Lawrence Livermore, the Government's laser-driven X-ray source was developed to simulate the focused X-rays needed to detonate the nuclear material within a fusion-based hydrogen bomb. The simulation lets researchers analyze the effects on the material housing the bomb of radiation sources of various types and power.

Joint efforts between Department of Energy weapons labs and industry top efforts by other Federal labs

Until recently, most X-ray lithography relied on synchrotron accelerators costing several tens of millions of dollars. In the United States, the only such device with anything approaching IC production capability is a $200 million facility built by IBM Corp. at its Advanced Lithography Area, part of the Advanced Semiconductor Technology Center in East Fishkill, N.Y. The facility built on work IBM did in the '80s at an experimental setup it ran at Brookhaven National Laboratory's Synchrotron Light Source. "Most efforts at companies and other laboratories are oriented toward more compact, lower-cost sources of X-rays," said Haskel.

Based on Lawrence Livermore's work with Hampshire ["Rethinking X-ray lithography," *Spectrum*, June 1992, p. 33–36], researchers there are now developing a number of Cradas with other companies. Haskel said the closest to completion is one with MRS Technology Corp., Chelmsford, Mass. Designed for the manufacture of LCDs with hundreds of pixels per square centimeter, the device will have five times the repetition rate and one-tenth the average pulse power of the one developed for Hampshire. The belief is that at the lower power, the X-rays generated will have the short wavelengths needed to fabricate submicrometer thin-film transistors.

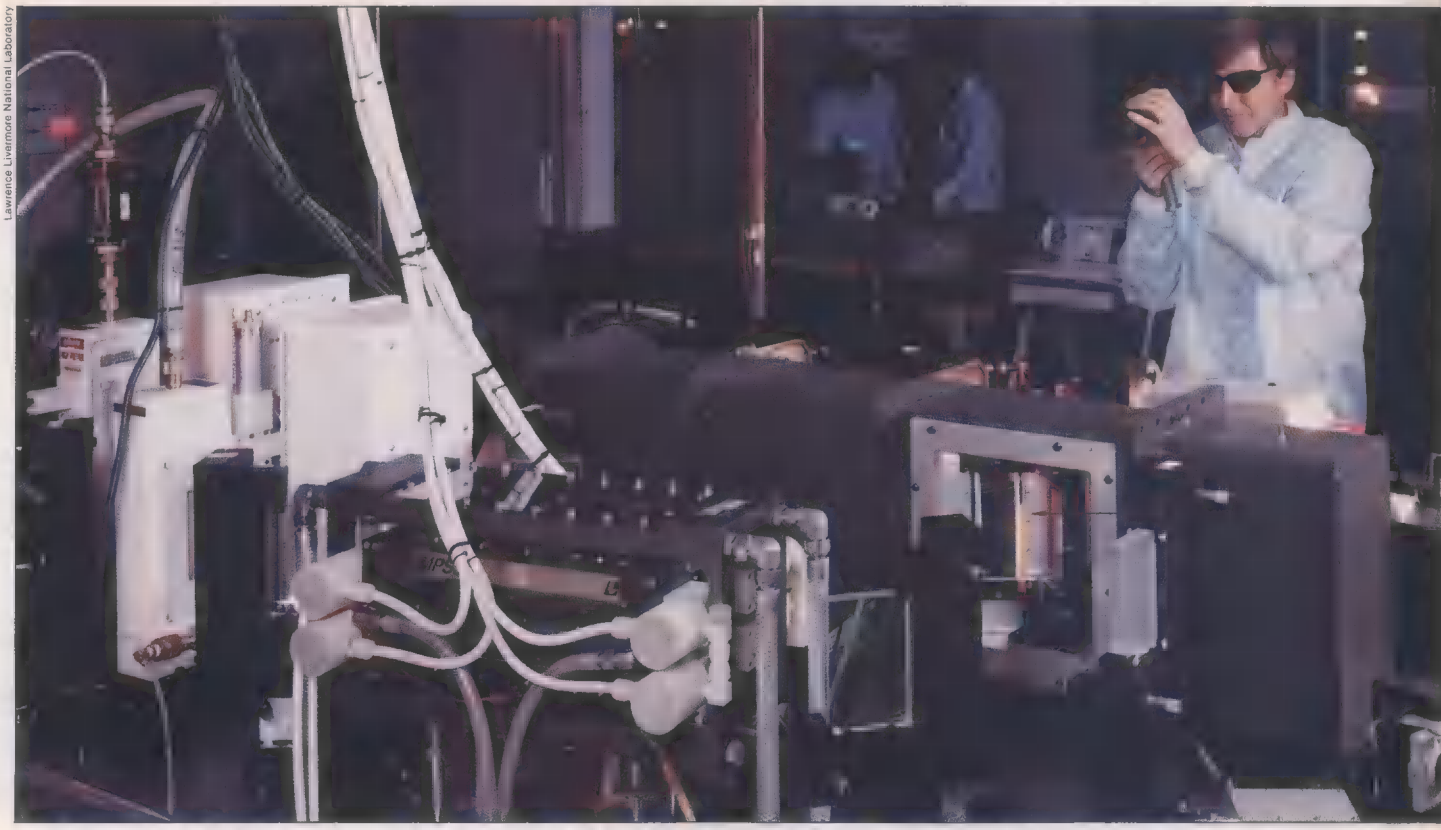
PROJECTION VS. PROXIMITY. Also targeting the next generation of 64M- to 256M-bit memory devices is another X-ray lithography system, being worked on at Sandia's California facility under one of the first Cradas approved by DOE. The company involved is AT&T. According to Rick Stulin, manager of the advanced materials research group at Sandia in Livermore, investigators believe they are close to a proof of concept in a compact prototype; the equipment uses X-rays with wavelengths of about 1.5 μm, in a projection scheme akin to early optical lithography systems.

The proximity approach being developed requires electron-beam–generated masks of about the same size as the pattern on the circuit. The Sandia-AT&T projection scheme is more forgiving. Its masks can have much larger features because the X-ray beam that passes through them can be reduced by means of a reflective optics scheme. Work so far has produced features as small as 50 nm, or 0.05 μm.

More recently, Sandia Laboratories have been successful in redirecting the advanced semiconductor-manufacturing capabilities used earlier to build radiation-hardened circuits for weaponry, according to Dellin. "If success can be measured by customers coming back to the store," he said, "then our Microelectronics Quality/Reliability Center must be counted a success." Sandia initially signed up two companies—National Semiconductor Corp. and Signetics Co.—for one-year pilot projects, and both have by now signed up for long-term Cradas. The facility has since January signed Cradas with two more companies—Olin Hunt Specialty Products Inc. and LSI Logic Corp.—and is now negotiating with some other companies.

Central to the center's efforts are its advanced characterization testbed capabilities,

Lawrence Livermore National Laboratory



Physicist Lloyd Haskel of Lawrence Livermore National Laboratory views an invisible infrared laser beam with a night vision telescope. The instrument is part of an X-ray lithography system used by the lab to form submicrometer features on silicon.

including wafer-level and packaged-parts tests, physical and statistical modeling, and in-line process monitoring. The center also has access to Sandia's expertise and equipment in nonvolatility, packaging, process control, product engineering, materials characterization, testability, and design. "Unlike most national laboratory activities, which generally plan in terms of years," Dellin said, "we have adopted a swat-team mentality, a quick-turn response approach. Often the problems our semiconductor customers come to us with are yield-killers."

In most cases, clients bring a sample of the problem to the lab. "But [we may] visit the client facility," he said, "or be up at all hours with a customer who is worried about a problem on the production line."

After a nine-month $6 million pilot project that ended in June, Sandia used the center's success to sell Sematech on a multiyear Crada. The agreement is for developing a center for research into contamination-free semiconductor manufacturing; potential annual funding is $20 million. The center's research will involve IC feature sizes as small as 0.1 μm and particles as small as 0.01 μm. The focus will be on the effects of chemical particulates as well as electrostatic, thermal, and electromagnetic radiation contamination.

While the new Crada structure for converting military research seems to be working, the system has its problems. Communications is one, according to opinions on the technology transfer program culled from company and national laboratory executives by Captain Audie Hittle, director of technology transfer at Hanscom Air Force Base, in Massachusetts. His survey was done for a master's thesis.

BIG BOTTLENECK. His respondents felt that, while the new Crada had speeded things up, one major bottleneck remained: getting information about what the laboratories offer and how it can be used out to the widest possible number of people in industry. "The company executives often said they didn't know what was available, while the laboratory executives said they didn't really know what the company executives needed," he reported.

In his view, how to disburse information about the capabilities available was the problem that should be addressed first, through outreach programs of all sorts. A step in that direction is the DOE's Technology Transfer Initiative, in essence a science and technology traveling road show. In the past year, more than 12 meetings were held around the country, attended by about 3500 representatives from private industry.

"However, this kind of thing has got to be more than a one-shot deal," said Peg Bogosian, director of technology transfer programs at Brookhaven National Laboratory. "It has to be ongoing." If she has any criticism of the DOE outreach effort, it is the continued orientation toward medium-sized to large companies. "What we need is a program for the small companies, from 100 people on down," she said. "A more effective model for this kind of effort may be the Department of Agriculture, [which managed] our country's first real success in technology transfer. It focused on the small farmer and made the United States the world's technology leader in agriculture."

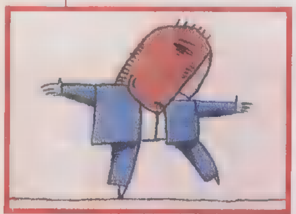
Bureaucratic and legal impediments to technology transfer are also a great concern, said Hittle. Rutledge of Sematech put it succinctly: "There are too many lawyers and backseat drivers." Agreements come fairly quickly at the engineering level, but "if there are even minor questions of liability and intellectual property, you risk an agreement being held up for months," he said. The issues admittedly are life and death to companies. For example, if a product developed using a particular lab's technology fails to live up to its advertising and its specifications, who is liable for damages?

If there is any secret to getting through the procedure quickly and with a minimum of problems, it lies in attitude and preparation, said Bullington. (His first Crada came through in six weeks, remember.) Rather than look on the labs as one vast R&D candy store, it is better, he believes, to view them more as a bookstore or library.

Essential to success, he said, are preparation and a good patent and intellectual property position. "You can't go in as a beggar looking for a technological handout. You have to go in with clear and specific goals and a sense of give and take. You want help solving a problem, so you have to give them something that helps them solve it." ◆

Learning new skills

Programs abound to retrain engineers for nondefense work, even though job availability is not guaranteed



With the dismantling of the Iron Curtain and the splintering of the former Soviet Union into an agglomeration of struggling new nation-states, the U.S. defense budget funding has become an object of desire for those eager to convert the so-called peace dividend into cash for a wide range of domestic programs.

But for the nation's defense and aerospace engineering community, "conversion" calls for a different game plan. For the contractors, it means finding commercial opportunities in ■ shrinking civilian economy. For the engineers and scientists who have seen their jobs vanish along with budget dollars, it means finding a new job and, in some cases, refocusing old skills and retraining to gain new ones. Many engineers who have spent their professional lives designing weapon and defense systems, or who have worked their way up to high salaries but are saddled with narrow expertise, now face the double trauma of choosing and learning ■ new specialty along with finding ■ job.

WHO SHOULD RETRAIN? How does one decide when and if to seek retraining or skills conversion, especially when some experts advise that training should come only as the last resort in ■ job-seeking strategy? And how does one select ■ training program from the dizzying variety available?

Traditionally in the United States, programs to aid laid-off workers have been started as discrete solutions; they rarely consider what has been done before. The result is, in the words of one government official, "administrative mayhem." Not only does the Federal government spend US $18 billion a year on 125 programs of all sorts, but the states compound the panic. Michigan alone offers 70 education and training programs overseen by nine departments.

Howard Wolff Contributing Editor

Added to this confusing mosaic of retraining opportunities are programs sponsored by almost every kind of government and private social service agency imaginable. Still others are offered by universities, defense companies [Table 1], and private organizations, while many churches and synagogues sponsor support groups.

One veteran of the field suggests learning a new specialty only if it is the kind of work the engineer enjoys doing. The key is "the 'fit' of [your] motivation to the training being offered," said Marlys Hanson, president of Marlys Hanson & Associates in Livermore, Calif., a specialist in career development for engineers and scientists. "We have found that the engineers who are laid off first are those who are the least motivated." Moreover, Hanson has found, these same engineers are also the least likely to find new employment.

EXAMINE OPTIONS. However, whichever job-seeking route is selected, the experts agree, the engineer must have a goal in mind—retraining is not just something to do until a job comes along. Examine the options available and select one; then do whatever retraining is necessary. Since programs spring up literally every day, the best way to filter out the better ones is to speak to their graduates.

> The engineer should have a goal—retraining is not just something to do until a job turns up

In the United States perhaps most retraining programs are to be found in southern California, which is packed with giant aerospace firms and has been hit especially hard by defense spending cuts. Many of the programs offered here aim to retrain engineers for work in the environmental industry, which is growing rapidly. One such program is offered by the University of Southern California (USC), which gives 20 unemployed aerospace engineers full scholarships, for a regular nine-month environmental-engineering curriculum.

An engineer participating in this program, Don Rivas of Cypress, Calif., said, "I'm one of the lucky ones." Laid off in July from his $48 000-a-year job at McDonnell Douglas Corp., where he designed computer systems to train airline pilots, he had quickly moved into a smaller house and cut back on unnecessary expenses.

Another fortunate engineer now at USC is Lai Chan, who until July helped design manufacturing systems for MD-80 jets at McDonnell Douglas. He came to the United States 16 years ago from Hong Kong and lives in Laguna Hills, Calif. Now, he jokes, "Everybody at work is considering volunteering to be laid off just to get into this program."

Planning to start its own retraining program next fall is the University of California, Irvine. "There is no question that areas like environmental engineering, biomedical engineering, and transportation technology seem to be getting more interest," said William Sirignano, dean of engineering. The school will offer its first undergraduate studies in environmental engineering and is considering graduate-level courses in the field as well.

Some engineers get retraining help before they are laid off through another program in California. The Calstart transportation consortium, Burbank, has won a $1.8 million contract from the state's Employment Training Panel to help workers make the transition from aerospace to the emerging electric-vehicle sector. The hope is that program participants will take their new know-how back to their companies.

"What it will do is help us prepare California aerospace companies to serve the global automotive market," said Lon Bell, interim president of Calstart. Added Ada Carrillo, manager of planning and research at the Employment Training Panel: "We're really committed to trying to keep companies in California and to prevent unemployment from occurring in the first place."

Also in the Los Angeles area, the Los Angeles County Private Industry Council has set up its own intensive integrated training in environmental engineering for unemployed engineers. The 14-week training schedule is rigorous: six hours a day, five days a week (including one or more Saturdays) for a total of 425 hours.

HELP IN A HURRY. But the most effective cry for help by the newly furloughed engineer could be a phone call to the nearest job bank.

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State University of New York at Stony Brook

Engineers Jon Uebel, Alfred Milletari, and Walter Nazimowitz, from left, all in the State University of New York at Stony Brook's retraining program, confer with research associate Barbara Panessa-Warren of the university's Harriman School for Management and Policy.

Members of the Southern California Section of the IEEE have set up two banks staffed by nonworking volunteers. They are in San Diego (619-453-1493) and Anaheim in Orange County (714-758-1361).

The IEEE also offers its members the Professional Engineering Employment Registry (PEER II), a computer database service that matches job seekers with job openings [''Resources and contacts,'' p. 68].

Typically, the job bank in Anaheim is staffed five days a week. In off-hours, answering and fax machines are used. The operation chiefly seeks to match job seekers with job openings, which are listed after local employers contact the bank.

One of the prime movers at the Anaheim job bank is Bob Gauger of Irvine, Calif., who 15 years ago moved from aerospace engineering to the private sector. Several years later, he became a consultant in reliability/availability engineering and risk assessment. Today he is enthusiastic about the concept of job banks. ''The skills banks or job banks offer a no-cost preliminary screening for the employer,'' said Gauger. ''We hope to start several more around the L.A. area, with the next one expected to be at Cal State Long Beach.''

DISCRIMINATION? But Gauger reports one disquieting element of the Southern California job-hunting scene. ''Some companies refuse to accept résumés with anything on them about military or aerospace employment,'' he said. ''One Los Angeles–based engineer contacted IEEE headquarters because of the discrimination. In checking this out with local Orange County unemployed aerospace engineers, I found it was true. They are being told to hide or modify all aerospace experience because they can't get an interview if it is shown on their résumé.''

''That's rank discrimination,'' he continued, ''although the companies do have a point: in defense and aerospace, the engineering level is higher, and there is more paperwork and less cost-consciousness.''

That view seems to be pervasive; a review of the employment situation in *Business Week* magazine last summer put it this way: ''Even highly skilled engineers sometimes have trouble finding jobs, tainted by the defense industry's reputation as being bureaucratic, late to market, and frequently over cost.''

Helen Gracon, program director at ProMatch, Sunnyvale, Calif., listed for her clients the stereotypical perceptions they are likely to confront when they interview for commercial jobs [''No more job security,'' p. 63]. Interviewers may feel, for example, that defense engineers are not cost-conscious, design overengineered products, lack accountability, overemphasize paperwork and documentation, and tend to watch the clock.

For their part, defense engineers have their own prejudices, Gracon noted. They may feel that commercial/industrial projects are undisciplined, exercise few controls, accept lower quality, are oriented to the short term, and encourage a ''sweat shop'' mentality. Worse, ''ex-hippies'' are often in charge. Gracon recommends that defense engineers discard such attitudes.

On the opposite coast, New York State's Long Island, home to Grumman Corp. and other defense contractors, is also experiencing a high unemployment rate among engineers. Attacking the problem, the State University of New York at Stony Brook (SUNY) and employers in the region have set up The Jobs Project, a graduate-level program that takes a unique approach to the conversion problem. Joseph Pufahl, co-director, said, ''One creates jobs, one does not find jobs. We are taking engineers through the process of beginning to believe that.''

NO NEAT CIRCUITS. Said Pufahl, ''The out-of-work engineer must find ways in which his skills are valuable to business. He must lose the idea that there is a list of jobs: there is no such thing. Most opportunities are 'open' systems. They aren't nice neat circuits. It's not like in defense where you work on, say, a communications subsystem that fits into an F-14B.''

However, Pufahl believes that the job seeker should get in touch with a business school to build managerial skills, should phone companies and ask questions, and research an industry to see where the problems are.

Focusing on these goals, The Jobs Project's course list includes management techniques in technology, information systems, the environment and hazardous materials, and electron microscopy (Long Island could become a hotbed of materials research, Pufahl believes).

One student in the program is using it as just part of a two-pronged job-seeking strategy. Jon Uebel, at 28 years old the youngest participant, was laid off last April by Grumman in Bethpage, N.Y. During much of his four years there, he worked as liaison between engineering and manufacturing.

''I didn't do much job hunting,'' Uebel said. Instead he enrolled in a self-help program on Long Island called the Center for Practical Solutions. ''There I got some insight into writing proposals,'' he said. ''I did one for the Defense Department and another for the Department of Transportation.''

Now Uebel has his eye on a new start, in environmental waste management, as well as on study toward a master's degree. ''No way is this going to keep me from getting another degree,'' he said. ''I will look for a job during the day and go to school at night.''

One of Uebel's fellow students, a 59-year-old veteran of the layoff wars, is somewhat

discouraged and bitter. Walter Nazimowitz has been out of work since December 1991, when he was let go by Arkwin Industries of Westbury, N.Y., a maker of hydraulic gear for the aircraft and aerospace industries.

Nazimowitz, who is now receiving unemployment benefits of $300 a week but paying $550 a month for medical coverage for himself and his wife (which will increase after his Cobra coverage runs out in six months), said he's been laid off "four or five times before." His résumé is typical for a middle-aged engineer in the New York metropolitan area: United Aircraft, Fairchild, Curtiss-Wright, Grumman.

Between leaving Grumman and signing on with Arkwin, Nazimowitz spent 12 years with an air-pollution consulting company before it closed its New York City office. Now, he would like to get back into that field. "Since my latest layoff, I've sent out about 50 résumés," he said, adding that "I could have sent out 200, but in the air-pollution field requirements are narrow." He has had three or four interviews.

"In effect, I've worked for the Government for 35 years, but since I changed jobs, I have little to show for it," Nazimowitz says. As for his view of the SUNY program, Nazimowitz noted, "I'm getting a feel for the technology but not a working knowledge. I don't know what I'm going to do after the program ends. It's enlightening but broad, while jobs tend to be narrow."

A student in the Long Island program who is aggressively job hunting is Alfred Milletari of Huntington Station, N.Y. "My applications for a job in the waste-management industry are already in," said the 64-year-old engineer. He was laid off by an engineering firm, Nelson & Pope of Melville, N.Y., where he was a project engineer. Before that, he was with Grumman and Brinkman Instruments.

Milletari likes the SUNY schooling. "The program is helping me understand the problems involved in handling refuse," he said. "I already have ideas for possible system improvements." Milletari feels that the important thing in a retraining program is its thrust—it must "tell you what is out there." He would like more hands-on work, but understands that the course material cannot be too specific.

Not everyone is enamored of retraining, though. In fact, Anthony P. Carnevale, chief economist at the American Society for Training and Development (the professional society for human resources people, based in Alexandria, Va.), maintains that going back to school is the last thing to consider.

Carnevale, who also heads the Society's Institute for Work Based Learning, points out that "there is an amazing statistical congruity among all historical conversions" from a defense economy in both world wars, Korea, and Vietnam.

He said that 60 percent of defense and aerospace engineers who lose their jobs tend to get new ones within a year. Of those, about half earn 15 percent to 30 percent less in the new position, then take an average of five years to climb back to the previous level. As for the other half, according to Carnevale, about 30 percent take longer than five years to earn their way back, about 5 percent do better in their new jobs, and about 5 percent disappear from the job market.

Carnevale had this advice to offer to the newly unemployed engineer or scientist: "First and most important, do not get retrained. You didn't get your present job because you were trained for it; you got it by leveraging what you learned on the previous job and so on. People often use retraining as a device to stay in the denial phase or as a way not to re-enter the job market. Don't delude yourself: you have to get on with it. Find out what your prospects are and get moving."

GET COUNSELING. The first move, suggests Carnevale, is to get counseling as early as possible after you lose your job "as a kind

1. Placement help for displaced engineers

Company and location	Number laid off	Dates	Benefits and services								
			Severance pay	Job-search training	Office space	Job counseling	Personal counseling	Job banks[a]	Job fairs	On-site retraining	Off-site training funds
Lockheed Corp., Burbank, Calif.	N.A.	N.A.		C	C	C		C+G	C		
McDonnell Douglas Corp., Long Beach, Calif.	1990	7/90–6/91		C+G	C+G	C+G	C+G	C+G	C+G		G
Northrop Corp., Los Angeles (multiple sites)	1200[b]	1/90–12/90		C+G	C	C	G	C+G	C		G
Rockwell-North American Aircraft, Los Angeles	160	10/89–12/90	C	C	C	C	C	C	C		G
General Dynamics Corp., Electric Boat, Groton, Conn.	75	10/90–1/91		C	C	C	C	G			G
UNC Naval Products, Montville, Conn.	240	2/90–12/90	C	C+G	C	C+G	C	G	C+G		C+G
Boeing Co., Wichita, Kan.	60	1/90–12/90		C	C	C				C[c]	
GE Aerospace, Burlington, Mass.	150	1/91–12/91	C	C	C	C+G	C+G	C+G	C	C+G	C+G
General Electric/ GE Aircraft Engines, Lynn, Mass.	350	10/90–2/91	C	C	C	C	C	C	C	C	C
McDonnell Douglas Corp., St. Louis, Mo.	1900	7/90–6/91		C/G[d]	C/G	C/G	C/G	C/G	C	C	G
Grumman Corp., Long Island, N.Y.	230	1/90–12/90	C	C		C			C		G
Texas Instruments Inc., Dallas	700	1/90–5/91	C	C	C	C	C	C	C	C	C+G
General Dynamics Corp., Fort Worth, Texas	2500	6/90–6/91		C	C	C	C	C	C+G		G

C = company-operated and -funded; G = government-operated and -funded; C+G = joint operation; C/G = company-operated, government-funded; N.A. = not available.
a Every state employment service maintains a job bank; displaced engineers may, however, rely primarily on job listings developed at the company outplacement center.
b Includes engineers and other white-collar jobholders.
c Company cross-trained 176 engineers for other jobs in-house.
d C/G programs were company-provided until November 1990, then turned over to government agency.
Source: "After the Cold War," Office of Technology Assessment, 1992

2. Age and unemployment among EEs, early 1990

Region	Unemployed engineers as percent of age group	
	55 and up	Under 55
Northeast	1.7	1.8
East	1.7	1.3
Southeast	3.0	1.2
Central	3.7	2.2
Southwest	1.7	1.8
West	3.1	0.9
United States	2.4	1.5

Source: IEEE Member Opinion Survey, 1990 (adapted)

of reality-testing process and a means of viewing yourself as still a useful member of society. This will help you determine who you are and what you are—that is, what skills you have and where you are in your career.''

Second, he said, ''Build a peer support system with others involved in the same process. Join a job club; meet regularly with others. If your company offers outplacement aid, take advantage of it.''

Third, ''identify jobs or prospects.'' The best thing to do when you don't have a job is to find one, but make the job hunt as structured as you can, he added.

Finally, only after going through this process should you decide whether you need new skills or training.

One thing to consider is that ''employers can't find exactly what they want anyway, so they hire people who can learn on the job,'' pointed out Henry Kelly of the Office of Technology Assessment, Washington, D.C. Kelly was director of the agency's project on Technology and the American Economic Transition. He adds that groups such as Sematech Inc.—the electronics industry's semiconductor-manufacturing R&D consortium based in Austin, Texas—are looking for corporations willing to fund graduate training in specialties that would guarantee a job.

> Engineers may not get interviews if aerospace skills are on their résumés

Another warning about overenthusiastic retraining comes from John Guarrera, Past President of the IEEE and director of research at the School of Engineering and Computer Science at California State University, Northridge. ''Jobs must be available or retraining doesn't mean anything,'' Guarrera said.

''The problem isn't a lack of competency but a lack of jobs. A well-trained engineer can take any job within reason.'' [See ''Tax incentives, not retraining, is the answer,'' p. 63.]

TEACHING INNOVATION. Echoing the caveat of other experts is Joseph Bordogna, head of the Directorate for Engineering of the National Science Foundation (NSF), Washington, D.C. He said that while ''there is an urge to do something, thinking is quite embryonic. There is a large skilled and enabling workforce busy producing products for a specific purpose; the way they do that is different from civilian production.''

''Is it necessary to reenable them to go from defense to civilian work?'' he asked. ''Design, manufacturing, and goals are different. Needed is more reeducation—teaching how to innovate—rather than retraining in specific skills.''

''There are several ideas being tossed around at the NSF, and given the pressure that the Congress is under to do something, we should see a plan emerge in a year or two,'' Bordogna predicted.

In describing two possible envelopes for retraining, Bordogna said the first would be technology- rather than need-based. It would teach how to approach civilian technology and broaden horizons by offering courses in manufacturing, computing, and materials technologies. The 12-month practice-oriented study would lead to a master's degree in engineering.

Two broad teaching areas would be highlighted. One would cover advanced manufacturing and information technologies, an update on advanced materials technologies, and, perhaps, biomedical technology. The second would cover such items as organizational behavior, total quality control, and finance—that is, how to start a small company or how to start an enterprise within a large company.

The second retraining envelope involves a kind of G.I. Bill of Rights for women and minorities that would help to stem the current shortage of professors. Since the Armed Forces have recruited highly qualified women and minorities, the new G.I. Bill would bring these people into engineering doctorate programs. If the participants complete the programs and eventually teach for a certain number of years, costs for their studies would be forgiven.

Finally, said Bordogna, there are 18 Engineering Research Centers on campuses, funded by NSF, that could be used for retraining.

EMPLOYMENT PICTURE. Meanwhile, the employment picture for the engineering profession in general and the defense/aerospace engineer in particular is not a pretty one. Behind the human pain and anxiety of laid-off engineers and scientists are the cold statistics. Estimated employment in the industry—including all workers, not just engineers—will drop to the 2 million range by 1995, according to Department of Defense estimates. For the 1991 fiscal year, says the Pentagon, the total was 2.9 million.

On top of that, there is the lingering recession. Job cuts after other wars have been worse. But the unemployed in those years were living in a nation whose economy was surging.

The National Science Board, Washington, D.C., forecasts a period of relative stability in the 1990s for the overall science and engineering labor markets. That means a stasis, with everything standing still—indicating that finding a job in the '90s will take a lot more effort than it did in the last decade.

Estimates of engineering unemployment vary, and data are difficult to interpret. The IEEE has data from a member survey in 1990 [Table 2]; another survey is planned for 1994. Robert A. Rivers of the IEEE United States Activities Manpower Committee reported a 3.9 percent unemployment rate for the second quarter of 1992. But Rivers is concerned that his future forecasts, which show a drop in unemployment to 1.26 percent in the third quarter of 1993, may be inaccurate. His forecasting model is based in part on interest rates set by the U.S. Federal Reserve Board and may no longer correlate with actual unemployment levels because a weaker bank system no longer responds by lending more to business and industry when interest rates are reduced. Stung by bad loans, primarily for real estate, in the recent past, banks may choose to build up their reserves instead of lending. Thus, the Federal Reserve Bank may have lost much of its influence over lending practices, and an economic environment may now exist in which the old relationship between interest rates and job-producing investments no longer applies.

Moreover, studies show that displacement of engineers is at least twice as great as the number of unemployed. Many accept nonengineering jobs; a former engineer who now manages a motel, for example, would not be classified as unemployed.

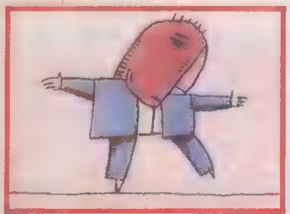
A survey designed to determine the employment status of members of the IEEE's Long Island Section adduced statistics that Section chairman John Pierro, of AIL Systems Inc., Deer Park, N.Y., called ''staggering.'' The survey took the form of a ballot printed in *The Pulse*, the Section's newsletter. It generated 124 responses from members; 30 of them were retired, 20 unemployed involuntarily, and five employed but seeking a change back to their area of primary competence.

''If you subtract the retirees,'' said Pierro, ''we are left with 94 people, 25 of whom are either unemployed voluntarily or seeking a job change. This constitutes 26 percent of the total response.''

Pierro believes that engineers are in the midst of the worst unemployment crisis in history. Unemployment statistics are grossly understated, he said, and could be two to three times as high as the number quoted by Government agencies.

The courage to convert

Government may help, but engineers—and businesses—must work out their own destiny, say those who know the challenges



To a greater extent than many of us perhaps realize, the economy of the United States—especially its high-technology sector—has been shaped by military considerations. A significant fraction of U.S. engineers and engineering companies have no experience competing in that other world, where customers expect excellent products to be designed and delivered in practically no time and at low cost.

How will these people and institutions fare in a world in which the threat of superpower conflict has been removed? *IEEE Spectrum* asked a variety of people who know the field, most of whom agreed that the engineering community (both the companies and the individuals) must take the lead in adapting to the new reality.

Although the details of their views vary greatly, all agree that fundamental change is taking place and that Government will have a major role to play.

Michael J. Riezenman Senior Editor

Government must play a role

Jacques S. Gansler, TASC

Industry must take the lead in the conversion from a military to a civilian business orientation. Not only is that the American way, it also puts the responsibility for action with the organizations that are most concerned with the results. That said, it must be recognized that the Department of Defense (DOD), as the sole buyer of military equipment and the regulator of the defense marketplace, must assist in this activity.

Two key questions arise in considering the role of the Government in conversion: is it possible to use the declining—but still very large—annual defense budget to strengthen both U.S. security and U.S. competitiveness? And is it possible to restructure the defense industrial base by the beginning of the 21st century to provide security while simultaneously aiding U.S. industrial competitiveness?

Historically, the public policy issues of security and competitiveness have been viewed at best as independent, and more often as in conflict. Now they must be assessed together.

Even though the Cold War is over, worldwide peace and stability do not exist—nor are they likely to anytime soon. Most recently, the Desert Storm conflict showed that we need to develop and produce much new equipment (global surveillance equipment, all-weather precision-guided weapons, and antiballistic missile systems, to name just a few).

The problem is that, with the high and rising cost of defense equipment and the projected decline in defense budgets, the United States may be able to afford only very little of such equipment. (That, of course, will make unit costs higher still.) Additionally, huge subsidies will be required to maintain standby industrial capability for possible production surges in periods of crisis. Clearly, neither of these will be affordable with the diminishing defense budgets.

Thus, the first need is for defense R&D to focus on reducing the costs of military equipment—complementing its historic (almost sole) focus on weapons performance. This requires dramatic shifts in the military requirements process, to include a weapon's cost among its relevant parameters; and, in engineering design practices, to fully utilize concurrent engineering—that is, to consider manufacturing and support during the preliminary design. Also needed will be a reallocation of resources—to balance the R&D focus on *product* technologies with a far greater focus on manufacturing and information *process* technologies.

These changes would not only mean a totally different way of doing defense business; they also would move the weapons acquisition process toward the modern commercial way of doing business.

Today, defense industry downsizing is a random process driven mostly by domestic politics (''pork'' and ''protectionism''). What is missing is a clear vision of how the United States wants its defense industrial base to be structured in the 21st century.

Free market forces do not operate here to achieve efficiency and effectiveness. Government actions totally control this marketplace through laws, regulations, and procurement practices.

Because of the impact technology has on both military effectiveness and economic competitiveness, three recent trends in its use may help determine the best 21st century structure for the defense industrial base.

First, today civilian products—such as electronics and new materials—frequently exceed defense product performance, yet they are often cheaper, of higher quality, and operate in equally rigorous environments. (A computer chip mounted directly on an automobile engine block has a more extreme environmental requirement than a military chip, and it will be expected to tolerate it for a lot longer.)

Second, on the production side, world-class corporations today are moving from mass production toward ''flexible manufacturing,'' which achieves high efficiencies with multi-product, low-volume operations. Flexible manufacturing makes it attractive to build commercial and military products in the same plants if the products require similar production processes.

Third, a list of those critical technologies required for future military equipment today (as published by the DOD) includes such items as advanced electronics, new materials, software, advanced manufacturing equipment, and advanced information systems. Not surprisingly, the Department of Commerce's list of ''emerging technologies'' critical to international competitiveness in the 21st century has more than an 80 percent overlap with the DOD list.

Based on these trends, many now believe that the only way the Department of Defense can afford to provide a peacetime and crisis industrial base is to adopt a structure combining very few ''defense unique'' sectors with many more fully ''integrated'' sectors.

This must encompass three forms of civil/military integration: dual-use R&D; dual-use operations (common labor and facilities for engineering, production, and support); and buying of dual-use equipment, often at the subsystem, component, material, and software levels. All three forms of integration call for greater reliance on commercial buying practices, specifications, and standards.

This strategy does not mean simply buy-

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ing commercial items when they meet military requirements. It entails designing military systems around state-of-the-art commercial components, and building both defense and civilian products in the same plants—often on the same flexible production equipment. It further implies doing so with a single engineering and manufacturing labor force. And most important, for promoting both national competitiveness and national security, it means gearing R&D to satisfy future dual-use requirements.

Of course, this needed shift toward widespread integration of civil and military design and production is more easily said than done. The problem is not technological—it is the unique way in which defense business is done, with its own practices and procedures for accounting, auditing, and procurement. It also has its own set of specifications and standards for everything it buys and its own ways of dealing with data rights. And it omits cost in describing the requirements for a new weapon.

This unique business culture forms the principal barrier to integration and must be changed. Unnecessarily unique practices must be eliminated, and cost must be part of the weapons system specification.

Even if these dramatic changes in defense can be achieved—and I believe they must be—they will still not address many long-term competitiveness needs. Here, changes in macroeconomic policies as well as long-term R&D investments in other mission areas (like transportation, energy, environment, and education) are clearly required. But such a shift in defense practices is essential—and can be a big step in the right direction, for both the nation's military security and economic competitiveness.

—Jacques S. Gansler is senior vice president of TASC, Arlington, Va., a position he has held since 1977. He is a former deputy assistant secretary of defense, a former electronics industry executive, and the author of Affording Defense *and* The Defense Industry *(MIT Press, Cambridge, 1989 and 1980, respectively).*

Tax incentives are the answer

John J. Guarrera, California State University

"Retrain displaced aerospace engineers so they can be employed in the civilian sector!" So went the cry in the early 1970s when the U.S. defense budget was slashed, and so it goes today. It did not work then, and it will not work now.

What is needed instead are targeted tax incentives—tax breaks that apply only to investments in R&D leading to new products and services that would create jobs.

During the previous crisis, all the trade publications, many IEEE members, some company executives, and many people from academia and the Federal government agreed that aerospace and defense engineers needed retraining to work in the private sector.

The Government came up with money for the retraining, and many new programs were set up. Most of the displaced engineers accepted into these programs completed them successfully. Some even found employment. For the majority, however, the biggest benefits were the stipends they received for living expenses during the retraining period.

One retraining program moved 20 displaced engineers from defense and aerospace into the new field of ocean engineering. The 20 candidates were paid a modest salary for six months while they studied in their new field. They all finished the concentrated program with flying colors and participated in a graduation ceremony with families and friends.

Their joy was marred by just one serious problem: there were no jobs for ocean engineers. The 20 unemployed aerospace/defense engineers were then reclassified as 20 unemployed ocean engineers.

What went wrong? Apparently no one had bothered to find out whether there was a need for ocean engineers.

The real question is, are there jobs in the workplace for engineers? If there are, most could be filled by the displaced engineers without formal retraining. For jobs that require new skills, programs to retrain them are indeed in order.

During good times, with ample funding from government contracts, engineers are usually underutilized. There is, of course, a little bit of method in this madness—it allows companies to maintain reservoirs of engineers whose names and achievements can be listed on proposals for new contracts. But with extra time on their hands, engineers are expected to do their own menial chores of typing, copying, and delivering materials.

During tough times, such as we have today, the engineers remaining on the payroll are overworked. Still required to perform the menial chores, they also are expected to contribute overtime to help keep their employers competitive. Frequently, willingness to work unpaid overtime is a condition of employment.

These problems will not be solved by training a few engineers here and there. What is needed is massive investments for products and services that can put engineers to work.

My suggestion for accomplishing that is to go back to the scheduled income tax structure that drastically scaled taxes up for those with high incomes and then gave them special breaks like investment tax credits and reduced taxes on capital gains.

This time, however, I would have the tax breaks apply only to investments in R&D that are likely to lead to products and services that would create jobs. This strategy would unleash a host of products and services that were just waiting for the right stimulus. Allowing high rollers to take big risks offset by tax credits and deductions can turn our country back on.

—John J. Guarrera (LF) is director of the Center for Research and Services, School of Engineering and Computer Sciences, California State University, Northridge. He is a Past President of the IEEE (1974).

No more job security

Helen Gracon, ProMatch

Bad as it may be, the current economic recession is not the most important factor affecting engineering employment. More significant in the long run is the fundamental change under way in how businesses are organized. Companies are changing from large vertical enterprises into much smaller horizontal organizations.

In essence, they are downsizing themselves into relatively small entities, concentrating on their core businesses, and subcontracting everything else. Thus, they no longer need as many employees as before, nor do they need them on as steady a basis.

The effects of these changes on employees have been and will be profound: job security will no longer exist; everyone's most important project will be managing his or her career; time spent in a particular career will decrease; job competition will increase; and contract labor will become a way of life.

These need not be negative developments. In fact, they can be positive ones, provided that the members of the workforce recognize that they live in a changed and still evolving world, and must take a new approach to the business of earning a livelihood.

In his book, *The Age of Unreason*, Charles Handy says, "The organization which welcomes change can use that change instead of just reacting to it." He talks about the "shamrock organization," a three-leaved structure that works well when labor is plentiful and businesses can pick and choose among suppliers.

The first leaf in the shamrock is the business core of professional workers. These people alone can expect reasonable stability and security in a single career.

In the second leaf, contracts are signed with resource vendors—companies used by the core workers for specialty tasks such as manufacturing, maintenance, distribution, and marketing. Because the subcontractors are specialized, the work is done faster and more cheaply than it could be by the core organization.

The third leaf is the flexible supply of part-time and temporary workers who move into and out of companies as projects are started and completed. These people, some of whom are engineers, are the fastest-growing part of today's work force.

While the third-leaf workers lack the customary job security, they definitely can keep themselves continually employed. But they must revise their attitude toward their careers: accept that a full-time job may no longer be the norm, and that everything is negotiable.

Once this attitudinal shift has begun, engineers must rethink who they are and what they represent. They will have to start viewing themselves as collections of skills and assets to be sold or leased. And they will need to develop portfolios of sales materials—samples of their work; summaries of their abilities, education, and experience; and descriptions of their marketable products, services, and skills.

In hunting for and signing up prospects, job seekers will also need to consider how an assignment will affect their portfolios as well as their pocketbooks. For example, it may be wiser to accept a consulting job at less than the desired rate of pay if what they learn from it might bring in future contracts.

Taking responsibility for one's career will become even more important. To become career self-reliant, workers must continually assess and reassess their abilities and assets, and then look at the options available in the workplace. They will have to identify and stay current with industry trends and needs, nurture a network of industry contacts, and constantly refine their résumés to reflect current accomplishments and state-of-the-art abilities. Finally, they must be alert to new business and training opportunities.

Change will be the watchword, and adaptability will be the key to success. The outlook is neither so grim nor so simple as jobs disappearing. Rather, jobs will change. By the year 2000, only a third of the jobs will be performed as they are today; another third will still exist, but will be done differently and require new skills; and the rest will be jobs that do not yet exist.

Time spent in one career area will decrease. The Department of Labor has estimated that the average college graduate will have 48 years of employment, with five different careers and 12 jobs.

People in high-tech areas should plan on an average of only 2.3 years in any position. After that time, it is likely that the position will either disappear or evolve into something else.

The competition for those full-time jobs that do exist will increase. A Sunday newspaper ad now generates an average of 200 résumés. Four years ago, for each position employers interviewed four available people; now they interview eight.

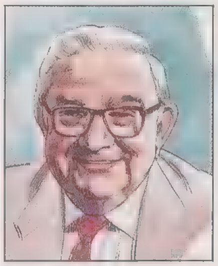
Contract labor will become a way of life. The number of contract workers has quadrupled over the past five years, and it is still climbing. The trend is clear: the person who retires from a company after 40 years of faithful service is an endangered species. The future belongs to the amoeba—the person who, like the one-celled animal, can constantly reshape himself or herself to adapt to changing conditions.

Careers are becoming a series of projects like those found in accounting, law, and construction—fields with a horizontal team orientation. It is this shift in career orientation to which engineers must adapt in order to be successfully employed in the '90s.

—Helen Gracon is a program director for ProMatch, a job club for professionals in transition sponsored by the State of California Employment Development Department in Sunnyvale. She has written a course curriculum, "Transitioning from Defense Aerospace to Commercial/Industrial," that has been presented to more than 500 professionals.

Needed: government support

George E. Brown Jr., U.S. House of Representatives



Little more than a year ago, our victory over Iraq demonstrated that U.S. defense technologies are undeniably the best on earth. Contrast that prowess with trends in the civilian economy: a shrinking share of the international market in high-technology products, and nearly 20 years of declining domestic living standards. We have neglected our civilian industrial base and now are paying the price.

The most incredible aspect of this state of affairs is that we did it on purpose. We knew that other nations were increasing their support of R&D in critical technologies. We knew they were steering low-cost capital toward their high-technology industries. We knew they were protecting domestic markets, promoting the transfer of technology from laboratories to factories, and training a highly motivated work force for high-technology manufacturing jobs. We knew all of this, but did not react.

As a result, we gave up world leadership in many of our most important industries: first steel, then automobiles and consumer electronics, and now computers.

The task facing us today is to restore our competitive position in world markets. Since the 1960s, our share of world merchandise imports has increased, our share of exports has dropped, and the living standard of our manufacturing workers has declined. In constant dollars, manufacturing wages are currently about where they were in the mid-1960s. Across the economy, full-time employees earn less, in constant dollars, than they did in 1969. We are flunking the competitiveness test.

At the same time, we are being presented with the unprecedented challenge of reshaping our domestic economy in the light of world political changes. Major reductions in our defense spending—long a primary force in our economy—are going to reshape our economy and our budget debates. We are facing a new definition of national security, one based upon global economic competition. As the global military confrontations of the past 40 years are replaced with economic confrontations, we need to redefine our national security in economic terms and develop programs in the civilian sector as focused and as aggressive as those we have had in the defense sector.

First and foremost, we need to give special attention to advanced technologies since they hold the greatest potential for future economic growth and employment opportunities. The list is fairly well defined and includes advanced electronics and materials, communication and information technologies, and biotechnology. What is missing is an orchestrated program of Government support for these technologies, which are so critical to our new national security.

Government support for advanced technologies isn't cheating and it isn't un-American. It's smart. This doesn't mean that we should copy every aspect of Japanese industrial policy—it isn't necessary and it wouldn't work. Nor does it mean that we should adopt an aggressively protectionist stance, because that would invite disastrous retaliation from our trading partners. What Government support for advanced technologies involves is focusing our existing programs on the restoration of national competitiveness.

To regain U.S. competitiveness, we need to create a favorable financial climate for reinvestment in our economy. We need to carefully phase in any defense cuts and move the budget walls brick by brick, placing defense savings carefully into critical civilian programs. We need to redirect a number of vital national assets, like our system of national laboratories, to focus on national economic security.

Specifically, we need a policy office at the White House that can provide this focus for our efforts. A critical technologies office would, with advice from the private sector and the states, identify the key technologies and design custom packages of Federal programs to help promote their development. Eventually, the functions of this office would move beyond an advisory role as the coordinating entity for our new national security effort.

Programs needed to boost critical technologies are already in place, but they need expansion. The advanced technology program, technology extension programs, international standards coordination, manufacturing technology centers, and other vital Department of Commerce efforts should all be expanded. Additional authority and funding is necessary to create Government-industry consortia to work on specific technologies.

We are currently spending about US $25 billion per year on research at Federal laboratories. This work should be reviewed and a modest sum, perhaps 10 percent of technology-related work, should be set aside for joint ventures with the private sector. In addition, the work of our three nuclear weapons laboratories should be reviewed. Weapons-development work should be con-

solidated, and the rest of the labs should be directed to technology development in critical areas.

Our tax policies should reflect the need for investment in these critical technology areas. We need to develop "patient" capital to allow commercial expansion in critical areas. Capital gains tax rate reductions for investments held at least five years in companies under $100 million in assets would direct long-term investment into start-up companies. Accelerated depreciation for critical technologies would open up domestic high-technology product markets. Making the R&D tax credit permanent would help as well. These tax policies are essential for an "investment-led" recovery of our competitive position.

To ease the pain of a shift from a defense to a civilian industrial base, a phased reduction in defense spending is needed, planned along a "threat-based" estimate of defense needs, such as Chairman Les Aspin (D-Wis.) of the House Armed Services Committee is currently conducting. Defense programs would be redirected to address our new national security needs and funding would be put into transition programs in technology development, worker training and retraining, and the creation of spin-off technology initiatives in the defense industry.

In meeting the economic challenges of a competitive world market, there is great need and opportunity. To turn this into a great victory, we need only the determination we displayed in the Persian Gulf.

—Representative George E. Brown Jr. (D-Calif.) is chairman of the House Committee on Science, Space, and Technology.

Converting a small business

Donald L. Schilling, InterDigital Communications

Small military businesses generally fall into three categories: support/service contractors, makers of a particular product or product line, and R&D firms. All three have been affected by cutbacks in defense spending, albeit in different ways.

In a particularly interesting position are the support/service contractors, which provide personnel to assist the Government or prime contractors in managing large contracts. With the reduction in military spending, the Government is paring down its own management infrastructure, and therefore may possibly need to rely more on support/service contractors. However, since large production contracts are being eliminated also, the bigger support contractors are taking an interest in contracts they previously considered too small. Thus, truly small businesses are feeling much stiffer competition.

Companies that manufactured to specific military needs are in many cases finding demand for their products diminished or even vanishing. Since commercial products, especially electronic ones, are progressing from generation to generation much faster than the Government can go through a development cycle, it is becoming less and less likely that any given Government-initiated development project will ever go to production. This is particularly true if the product has a commercial equivalent.

R&D companies usually bid on requests for proposals (RFPs) published in the *Commerce Business Daily* (CBD). The Government claims that while it is cutting production contracts, it will be increasing R&D contracts to "stay ahead." To date, however, this has not been the case. In fact, a comparison of CBDs from 1982 and 1992 shows that requests for R&D proposals have been slashed.

Most small businesses reacted to these developments by simply hanging on. Large oscillations in employment and contracts are, after all, a well-recognized fact of life in military engineering. As the frequency of the oscillation slowed, however, the layoffs began and closings followed. At this point the Government, recognizing the unique and serious problems faced by small businesses, stepped in and instituted a series of programs to help these companies.

One such program established an office at each Government procurement facility to ensure that a certain amount of work would be set aside for small businesses. Unfortunately, since some of these are much larger than others, the set-aside policy does not always benefit the ones who need it most—the truly small enterprises.

The Government also instituted a Small Business Innovative Research (SBIR) program with the object of presenting to small business companies a collection of problems that needed to be solved by different agencies. Small businesses were asked to respond with proposals for commercial applications. It turned out, however, that the problems that needed solving by the military agency rather rarely led to commercial uses.

One exception was the National Science Foundation (NSF), but its stated policy is to support basic research, not product development. Since a large investment is needed to move an R&D study project into production, small businesses are generally unable to capitalize on most of their good ideas.

Worse yet, it often happens that no proposal presented in response to a given problem is funded, for the simple reason that the SBIR office lacks the money. Yet preparing an SBIR proposal typically costs more than US $5000. How many times can a small business afford to throw away that kind of money before it decides to pursue other possibilities? It seems to me that this problem, at least, can be solved by preceding the proposal-writing with a brief meeting.

The Government also has a small business loan program. My company tried to contact the Long Island, N.Y., coordinator to arrange for a loan. The officer in charge was never in when we called and took an excessive amount of time to return calls. When one of our calls was finally returned, the officer did not know how to process our request, so it was forwarded to someone else. After several such "forwardings," we decided to give up on the loan program as a lost cause. As in the case of SBIR offices with no money, the Government here has the right idea, but is executing it very badly. It means well, but does not seem to know how to act effectively all the way down the line.

So, since a small business will obviously die if it waits for Government help, it must take the initiative itself. How? In the following three ways:

- Answer the CBD requests. Respond to as many SBIRs as possible, since they pay for research and allow the company to keep its engineering staff intact. Remember, firing good personnel is bad for morale and bad for future business.
- Look for a product that can be used by other companies or consumers. If you have a good idea, try to obtain a Government loan (good luck!). Better still, try to obtain venture capital. To do this, prepare a business plan showing how your company can take the idea to fruition, who will buy it, and how much the company will make. While estimates vary, venture capitalists (fondly called VCs) want the company's value after five years to be 5–10 times the dollars put in.
- Form a joint venture with a "big brother" company that has more money than you. To take this route, you must have something to offer the venture—your technical strength.

Although the Government cannot be relied upon to lead, it must play a role if small engineering companies are to survive. The help it supplies must be direct! Indirect help, like tax incentives, does not work when there is no income to tax.

Federal programs already in place must be strengthened with competent directors who are assured that they will be supported from above. The loan program, too, is essential. We recommend unsecured loans of up to US $1 million for developing products that can potentially be exported. A blue-ribbon panel should be formed to review the business plans submitted with the loan applications.

Loans that lead to successful products should be repaid, out of profit, with a 50 percent premium. Thus, for a $500 000 loan, $750 000 should be repaid if the product sells well.

I recommend that 100 loans be made each year. This program could be expanded by allowing private investors to buy stock in a joint Government-private company. The percentage of privately held stock could increase each year. Another option would bring in private money with a guarantee from the Government—like placing money in a bank or a savings and loan association. A similar program in Israel is now making a profit for the Government.

The NSF should play a major role in the economic development of the country. It must start funding product development; otherwise, there will be no products.

The SBIR program should be set up as a loan program—grants should be paid back when they lead to successful products. Properly managed, it can realize a profit for "Uncle Sam Investments."

Whatever actions are taken, they should be taken quickly. In all my experience of economic cycles, I have never seen a recession as severe as this one. It demands action, and soon. On the other hand, it does not require a lot of money. A modest increase in spending by the Government, if done in the right place and in the right way, can give an enormous thrust to the U.S. high-tech industry.

In the end, however, small businesses must help themselves. They have a lot to offer the country and the world. I hope that many *IEEE Spectrum* readers will put some effort into looking for viable product ideas, developing business plans, and finding financing. To paraphrase Franklin Roosevelt, they have nothing to fear but fear itself.

—Donald L. Schilling (F), executive vice president of InterDigital Communications Corp., wishes to acknowledge the time and effort spent by Dr. G. LeVeen in helping with this submission. Schilling recently retired as the Herbert G. Kayser Distinguished Professor of Electrical Engineering at the City College of the City University of New York. He has been a member of the Board of Directors of the IEEE and president of the IEEE Communications Society.

The challenge of peace

Edmund B. Woollen, Raytheon Co.

For the engineering community, which has made such enormous contributions to human progress during the 20th century, the new millennium offers an exciting but sobering challenge.

In light of the profession's impressive history, there is no reason to believe that—given the proper resources—it will not be up to the task. But the job will not be easy. Compounding the effects of the global recession are the watershed issues raised by the end of the Cold War. While the depolarization of East and West is certainly great news, it carries a stiff price tag in terms of lost jobs—a concern the U.S. Congress ought to weigh carefully as it evaluates both the positive and negative implications of a reduced defense budget.

Consider, for example, how deeply our engineering community has been immersed in the development and refinement of military defense systems over the past half century. Then consider the vacuum that would result from arbitrary cuts in defense spending. In Massachusetts alone, about 45 000 defense-related jobs could simply vanish over the next two years, elevating the Commonwealth's already high unemployment rate by two more percentage points by mid-1994. Many of those jobs are now held by engineers.

To help stem the tide, the Federal government should take a couple of bold steps: first, it should reduce defense spending gradually to soften the impact on the industrial community. Second, it should provide broadly based support for alternative programs calculated to serve the public good and to provide meaningful reemployment opportunities for affected workers, including our huge cadre of temporarily disenfranchised electrical and electronics engineers.

These initiatives could range from R&D grants for civil infrastructure improvements to financial support for new business development. The whole country would benefit if these professionals were put to work on such urgent tasks as rebuilding the nation's infrastructure, cleaning up its environment, and creating new globally competitive enterprises.

Nobody is suggesting that the Government carry the burden alone. Industry itself must adjust to the new reality—not necessarily by wholesale conversion from defense to civilian and commercial activity, but by diversifying its product mix to take up the slack. Bear in mind that, while defense needs will shrink, they won't evaporate. Defense contractors will continue to compete for a substantial amount of business. The pie will be smaller, however, and adjusting to the shortfall will challenge the best minds in government, industry, and the relevant professions—including engineering.

This is, of course, not an unexpected development to anyone with a modicum of vision. Prudent defense companies have long since diversified in anticipation of defense cuts. One tactic has been to adapt defense system technology to the civil and commercial markets. For example, radar technology, which is central to a variety of defense systems, is today just as much at home in air and vessel traffic control, global communications, and marine applications.

Larger contractors have also acquired companies far removed from the defense arena, entering markets ranging from environmental engineering to appliances.

Yet another hedge against budgetary shrinkage lies in the realm of foreign sales. Leading companies are tapping new global markets by supplying defensive systems and analogous products such as air traffic control systems to customers abroad.

Effective diversification calls for the transfer of generic engineering skills to new disciplines—after management first identifies appropriate markets. One caveat: while engineering skills are generally transportable, where those skills are applied is another issue. It would be foolhardy for a missile maker to enter the home entertainment field simply because it was familiar with the technology required to produce a television set. The missile maker doesn't know the home entertainment market and would be hard pressed to compete with the established players in the field.

Corporate management's task is to identify markets where its human and financial resources can make a difference.

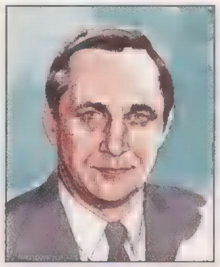
So for engineers, the solution to the employment crisis lies in teamwork. Government and private industry can and must pool their resources in a common quest for economic vitality in a changing world.

Engineers are a resource of incalculable value. They have responded nobly to the challenges of the 20th century. There is no reason to believe they won't respond just as effectively to the public infrastructure needs of the 21st, as well as to the host of commercial opportunities that will be the legacy of world peace.

—Edmund B. Woollen is vice president of corporate marketing for Raytheon Co. in Lexington, Mass. He has had extensive experience selling military and civil electronic systems both within the United States and internationally.

The pitfalls of conversion

Robert J. Polutchko, Martin Marietta Corp.



From its peak in the mid-'80s, defense spending has been reduced 30 percent and is still declining. Defense industries are finding it difficult to raise capital for new, nondefense pursuits or to achieve higher efficiency within defense activities. Too many companies are competing for too little business.

As a result, many concepts have been proposed for having defense contractors diversify immediately into commercial areas while simultaneously maintaining a viable defense industrial base. Those plans provide for a restructuring of that base to allow its competitive use for commercial applications while simultaneously keeping it capable of reverting to full defense production when necessary. The trouble is that most of these plans do not fully consider all the issues.

Frequently, they fail to explain how the associated business risks will be mitigated. Or where the money for commercialization will come from. Or how a company with a "defense culture" based on years of built-up policies, practices, laws, and regulations is supposed to change overnight into one with an appropriate "commercial culture." Or even how, in certain critical areas, the maintenance of an adequate defense capability can be assured.

In short, well meaning as they may be, such plans are often unrealistic. If the Government seriously wants to support diversification of the defense industry into nonmilitary areas, the burden is on the

Government to change. However, before making any new laws or policies, it should consult the defense industry. Even then, after new laws are enacted and new policies have been established, the Government must allow industry time to react with informed business decisions.

The defense industry's established base includes fiscal, marketing, and sales organizations, structured to sell to a single customer. Department of Defense regulations on cost accounting and allowability on cost of sales have caused us to develop unique ways of doing business, which must be considered in any proposed new direction. There are strict guidelines on what is permissible in defense R&D and marketing.

Distribution systems, too, have been uniquely designed for the Department of Defense. Converting that established base into a commercial sales force and distribution system cannot be done overnight or without large, nonrecurring expenses and considerable restructuring.

For military technologies, the defense industry has created unique R&D facilities. Any plans for the diversification of our technologies should consider the investment costs sunk in those facilities, as well as the skills and experience of the people who man them. Cost-sharing formulas for future, dual-use R&D are seriously flawed if no weight is given to industry's investments or to how industry's percentage is to be financed by already highly leveraged, low-margin business bases.

Not every company will choose to diversify. Some will stick to their knitting, where they may succeed or fail. In our free-market economy, there is nothing inherently tragic in a company failing; it happens every day. But in the case of some defense companies, failure may compromise the nation's ability to defend itself. To prevent that, the Government must ensure the viability of at least some providers of critical technology.

In a few cases, this may mean a single provider. Otherwise, we may find ourselves dependent upon foreign sources for our defense needs. Should that happen to any meaningful degree, decisions about our national security might be influenced more directly by foreign interests than we would like.

No one (I trust) will argue that the United States needs to maintain the defense industrial base that has served it so well in the past. The fruits of peace, gloriously won by the end of the Cold War, would have a bitter taste if, at the threats of the next Saddam, our defense options were to be constrained and we were unable to react with decisive force.

In light of these considerations, what can be done to minimize the risks to the viability of our defense industrial base? The following suggestions were proposed to Congress by Martin Marietta Corp.'s CEO, Norman R. Augustine:

- Assign highest priority to basic and applied research directed at major potential breakthroughs in military technology.
- Carry a sufficiently large number of hardware concepts into the prototype phase using competitive procurement practices.
- Begin engineering development of an item only if it is fully intended to procure it. Select a few highly promising "silver bullets" based on prototype demos. Establish production lines and design data packages to prove production hardware on "hard" tooling.
- Produce "silver bullets" at an efficient rate and then shut down the line. Maintaining a warm production base absorbs research funds that could better be spent on other promising technologies.
- Increase emphasis on inserting new technology into existing systems at the component level.
- Maximize use of commercially available components.
- Take steps to ensure the continued availability of critical elements of the defense industrial base—those with no commercial equivalents, such as research nuclear reactors like the advanced neutron source, stealth technology, precision-guided weaponry, and submarines.
- Review acquisition policies and regulations to eliminate inefficiency and turbulence.

One main purpose of the Federal government, as stated in the preamble to the Constitution, is: ". . .To provide for the common defense. . . ." Although a superpower conflict seems very unlikely in the foreseeable future, U.S. troops will undoubtedly be called upon again to risk their lives somewhere in the world. How well industry will be able to support them will depend on how "right-sizing" and diversifying into the civil sector is done. If done correctly, defense industry survivors and those that diversified and are able to swing back will be leaner, healthier, smarter, and better able to serve the national security objectives of this country in the new world order.

Therefore, those companies that decide, for good business reasons, to diversify into the civil sector should be given every chance to succeed. Federal policies must be changed and laws must be rewritten to support their efforts. However, well-intentioned but ill-conceived schemes to urge companies to switch from defense to dual-use or even pure civil business must be avoided.

One final cautionary word: because of the reduced number of defense-related production end-items being procured, the manufacturing sector of the defense industry is being seriously downsized. A defense industry move toward services and away from manufacturing is contributing to that trend. But beware: while it may be possible to base a national economy on service industries, it is not possible to win a war with one.

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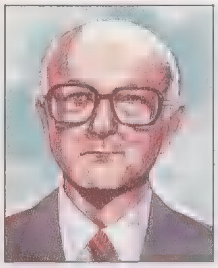
Self-help for aerospace engineers

Thomas F. Rogers



For years to come, we can expect to see Federal military space appropriations decrease. Civil space appropriations, which already seem to be capped, are likely to decrease as well. In sharp contrast, private sector space revenues are likely to continue to grow. Already at US $4 billion a year, they are rising at a 15–20 percent annual rate.

However, almost all of those private revenues are generated by a single business area: satellite communications. With few exceptions, such as weather research, all the $13 billion now allocated by the Government to civil space activities is used for basic research and solar system exploration. Whatever their long-term merit, such expenditures will do little for the nation's economic growth, employment, tax base, and international competitiveness.

Yet space offers a vast opportunity for economically attractive programs. The trouble is that most of the proposed programs require the establishment of at least a basic space infrastructure—the cost of which is paralytically high. Using Government infrastructure, electric energy is a thousand times more expensive in low earth orbit (LEO) than it is at the surface. Transporting a person to and from LEO costs 10 000 times as much as flying her across the Atlantic in a commercial aircraft. Housing someone in a LEO space station is projected to cost 100 000 times more than housing him on earth.

Ways can be seen for reducing such unit costs by orders of magnitude. However, almost none are being vigorously explored. Aerospace engineers, faced with declining prospects, have a stake in the pursuit of such projects. They should break with tradition and become active in making such programs happen.

I suggest they do three things:

- Join any form of technology development aimed at the sharp, swift reduction of the unit cost of basic space infrastructure. The most important areas are the surface-space and in-space transportation of people and cargo, as well as any in-orbit electric energy, habitation, and life support services. Senior engineers should work on their front offices to position their organizations as leaders in the development of unit cost reduction in space infrastructure.
- Enter the political process and work to see that elected and appointed officials understand that, for the rest of this decade, the highest national space priority should be to slash the unit cost of basic space infrastructure.
- Then, assume that these costs will come

down, and begin to think entrepreneurially about space activities. Lack of knowledge and experience is not necessarily a disqualification here; simply jump in and get wet all over. That is, engineers could talk to people, brainstorm ideas, conduct informal market surveys, and use their technical imaginations to determine what goods and/or services they could provide at a low enough price to a large enough market to make the whole project worth undertaking.

These engineers could try to persuade their managements to let them take these entrepreneurial steps, and even to cooperate with them in their efforts. They could go further and encourage colleagues and managers to invest in their initial undertakings. In time, with a sound business plan, the clear evidence of their commitment, and the support of their colleagues and front offices, they could obtain additional financing from more traditional sources of venture capital.

By taking this approach, entrepreneurially minded engineers would rapidly learn a great deal about real life in the private sector. What's more, their experience would be invaluable to others in their organizations as they move to expand their own private business activities.

For an initial period, Government support could be crucial for aerospace engineers and their employers working at expanding private sector space business activities. But, to date, most Government offices are not interested in doing so—their rhetoric to the contrary notwithstanding.

As proof of its reluctance to do so (or possibly just its inertia), consider that the National Aeronautics and Space Act of 1958, as amended, states: "The Congress declares that the general welfare of the United States requires that [the National Aeronautics and Space Administration should] seek and encourage to the maximum extent possible the fullest commercial use of space." Despite that legal requirement, only some 2 percent of the space administration's present budget is devoted to doing so.

Engineers must return to the basic notion that Government officials are servants of the people, not just sources of contract funds. Those officials should be informed by their engineering and related-business constituencies about the possibilities in space. Most of them are thoughtful, responsible, fair-minded people who would be happy to assist in shifting from public funding to private investment in space—if only someone would tell them what needs to be done and that they should do it.

The aerospace engineering community should insist that the Federal government now undertake a much greater effort to reduce its own space-related costs and, thereby, help private sector space businesses expand in character and magnitude.

—Thomas F. Rogers (LF) is a board member of three space-related private businesses, the president of a space association, and chairman of the IEEE's Aerospace R&D Policy Committee.

Resources and contacts

Beyond Spinoff: Military and Commercial Technologies in a Changing World by John A. Alic et al. (Harvard Business School Press, Boston, 1992) discusses the need to rethink the relationship between the military and commercial sectors.

In "Survival Guide for Defense Contractors" (*Electronic Business*, July 1992), Peter Burrows offers advice on how to weather the shakeout in defense electronics.

The Office of Economic Adjustment (OEA) of the U.S. Department of Defense provides a packet of materials on Defense Economic Adjustment programs along with lists of OEA defense industry community contacts. The packet is available from Director Paul J. Dempsey's OEA office, The Pentagon, Room 4C767, Washington, D.C. 20301-4000; 703-695-1800.

The Library of Congress' Congressional Research Service (CRS) published the report "Federal Economic Aid to Communities, Workers and Business Affected by Defense Cuts" on Jan. 11, 1991. Another useful CRS publication is "Defense Spending and the Economy: Selected Annotated References, 1985-1991," December 1991. All CRS publications are available through the office of your local congressional representative.

The *Regional Review*, published by the Federal Reserve Bank of Boston, devoted its Fall 1992 issue to "Moving the Economy out of Defense." The journal is available from the Research Library-D, Federal Reserve Bank of Boston, Box 2076, Boston, Mass. 02106-2076; 617-973-3397.

The Center for Economic Conversion assists people in military-dependent localities and states to develop and implement economic adjustment strategies. The center is located at 222 View St., Suite C, Mountain View, Calif. 94041-1344; 415-968-8798.

The National Commission for Economic Conversion and Disarmament, chaired by Seymour Melman, publishes *The New Economy*, a periodical containing conversion news. It also publishes briefing papers, including "How the Military Service Firm Differs from the Past" by Anthony DiFilippo, March 1991. The commission is located at Suite 9, 1801 Eighteenth St., N.W., Washington, D.C. 20007; 202-462-0091.

Employment Research Associates, a nonprofit consulting firm specializing in the impact of government policies in the U.S. economy, published "Converting the American Economy: The Economic Effects of an Alternative Security Policy" by Marion Anderson, Greg Bischak, and Michael Oden, in 1991. It is available from Employment Research Associates, 406 Hollister Building, Lansing, Mich. 48933; 517-485-7655.

Two recent reports urging new policies for the nation's Federal laboratories are "Industry As a Customer of the Federal Laboratories," prepared by the Council on Competitiveness (900 17th St., N.W., Suite 1050, Washington, D.C. 20006; 202-785-3990), and "Transfers of Technology to Industry from the U.S. Department of Energy Defense Programs Laboratories," published by The Atlantic Council of the United States (1616 H St., N.W., Washington, D.C. 20006; 202-347-9353).

The Federal Laboratory Consortium for Technology Transfer is a clearinghouse for research under way at the U.S. national laboratories. Contact Andrew Cowan, DelaBarre and Associates, Box 545, Sequim, Wash. 98382; 206-683-1005. The National Technology Transfer Center links private firms with specific needs to the appropriate scientists in the Federal laboratories. Contact Lee Rivers, Wheeling Jesuit College, 316 Washington Ave., Wheeling, W. Va. 26003; 800-678-NTTC or 304-243-2455.

Among formal retraining programs are the Los Angeles Private Industry Council Training Program (apply at offices of the California Employment Development Department in Hollywood, Lancaster, North Hollywood, Pasadena, Torrance, and West Covina) and The Jobs Project (contact Joseph Pufahl, codirector, State University of New York, Stony Brook, N.Y. 11794-1760; 516-632-6310).

Many Sections of the IEEE offer members assistance in finding jobs. An example is the IEEE Boston Job Bank; contact Irving L. Weiner, 2411 Bay Rd., Sharon, Mass. 02067. Another is the IEEE Orange County (Calif.) Skills Bank; contact Ted Williams, Box 11225, Santa Ana, Calif. 92711.

The IEEE has contracted Success Systems Inc., Torrance, Calif., to run the Professional Engineering Employment Registry (PEER II) for IEEE members in the United States. Subscribers receive a DOS-compatible diskette that lists jobs matched by a computer to their specific qualifications and requirements. In addition, Success Systems enters subscribers' résumés into a database accessible to potential employees. A year's subscription of US $15 entitles an employed member to three diskettes. An unemployed member may obtain four diskettes a year. For application forms, contact the IEEE United States Activities Board (IEEE-USA), 1828 L St., N.W., Suite 1202, Washington, D.C. 20036-5104; 202-785-0017.

The IEEE also publishes an *Employment Guide for Engineers and Scientists* in two volumes: a manual on how to obtain a job and a directory of IEEE employers listed by state. The *Guide* is available through the IEEE Service Center; 800-678-IEEE. It is free to unemployed IEEE members; contact the IEEE-USA. The IEEE-USA also supplies information on how to develop local employment assistance programs.

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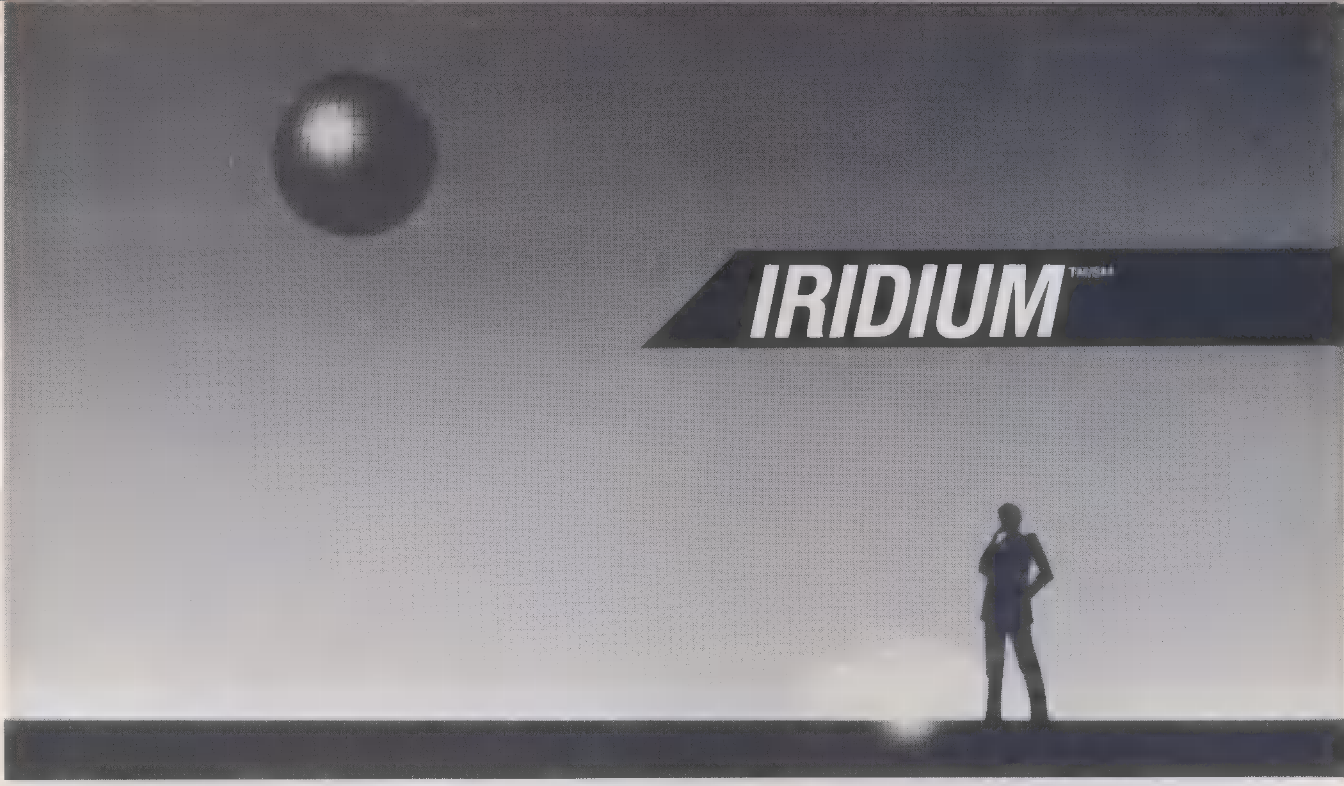
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Packaging Handbook. *Intel*, Intel, Mount Prospect, Ill., 1992, 352 pp., $19.95.

Power Programming with Microsoft Macro Assembler. *Duncan, Ray*, Microsoft Press, Redmond, Wash., 1992, 384 pp., $39.95.

Digital Control Systems: Theory, Hardware, Software. *Houpis, Constantine H.*, and *Lamont, Gary B.*, McGraw-Hill, New York, 1992, 752 pp., $61.55.

Programmable Logic. *Intel*, Intel, Mount Prospect, Ill., 1992, 565 pp., $19.95.

The Essential Guide to MS-DOS 5 Programming. *Aitken, Peter G.*, Microsoft Press, Redmond, Wash., 1992, 464 pp., $24.95.

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Developing Object-Oriented Software for the Macintosh: Analysis, Design, and Programming. *Goldstein, Neal*, and *Alger, Jeff*, Addison-Wesley, Reading, Mass, 1992, 347 pp., $26.95.

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Memory Products. *Intel*, Intel, Mount Prospect, Ill., 1992, 1104 pp., $21.95.

The Modern Amplifier Circuit Encyclopedia. *Graf, Rudolf F.*, TAB/McGraw-Hill, Blue Ridge Summit, Pa., 1992, 194 pp., $12.95.

Electrical Circuits: An Introduction. *Smith, K.C.A.*, and *Alley, R.E.*, Cambridge University Press, New York, 1992, 578 pp., $115 (cloth), $44.95 (paperback).

Peripheral Components. *Intel*, Intel, Mount Prospect, Ill., 1992, 1376 pp., $24.95.

PHIGS Programming Manual: Describes 3D Programming in X. *Gaskins, Tom*, O'Reilly & Associates, Sebastopol, Calif., 1992, 120 pp., $52.95 (hardcover), $42.95 (softcover).

Kings of Creation: How a New Breed of Scientists Is Revolutionizing Our Understanding of Dinosaurs. *Lessem, Don*, Simon & Schuster, New York, 1992, 367 pp., $25.

Microcommunications. *Intel*, Intel, Mount Prospect, Ill., 1992, 1440 pp., $26.95.

Dictionary of Information Science and Technology. *Watters, Carolyn*, Academic Press, San Diego, Calif., 1992, 300 pp., $29.95.

Quality Engineering Handbook. Eds. *Pyzdek, Thomas*, and *Berger, Roger W.*, Marcel Dekker, New York, 1992, 617 pp., $99.75.

TOG on Interface. *Tognazzini, Bruce "Tog,"* Addison-Wesley, Reading, Mass., 1992, 331 pp., $26.95.

Inside AMI PRO 2.0: Professional Tips & Techniques. *Hoath, Maria A.*, Windcrest/McGraw-Hill, Blue Ridge Summit, Pa., 1992, 588 pp., $24.95.

The Papers of Thomas A. Edison, Vol. 2. Eds. *Rosenberg, Robert A.*, *et al.*, Johns Hopkins University Press, Baltimore, Md., 1992, 842 pp., $75.

Manufacturing Systems: Foundations of World-Class Practice. Eds. *Heim, Joseph A.*, and *Compton, W. Dale*, National Academy Press, Washington, D.C., 1992, 273 pp., $34.95 (cloth), $19.95 (paperback).

High Tech Fantasies: Science Parks in Society, Science and Space. *Massey, Doreen, et al.*, Routledge, Chapman & Hall, New York, 1992, 268 pp., $79.50 (cloth), $23.50 (paperback).

Macintosh System 7: The Complete Sourcebook. *Campbell, Gordon M.*, Windcrest/McGraw-Hill, Blue Ridge Summit, Pa., 1992, 357 pp., $32.95.

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Circuits: Principles, Analysis and Simulation. *Yatsko, Frank P.*, and *Hata, David M.*, Saunders College Publishing, Fort Worth, Texas, 1992, 973 pp., $42.

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Microprocessors, Vol. II. *Intel*, Intel, Mount Prospect, Ill., 1992, 1260 pp., $25.95.

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Widegap II-VI Compounds for Opto-electronic Applications. Ed. *Ruda, Harry E.*, Chapman & Hall, New York, 1992, 415 pp., $89.95.

Introduction to Electrical Engineering, 2nd edition. *Paul, C.R., et al.*, McGraw-Hill, New York, 1992, 771 pp., $43.95.

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Foundations for Microwave Engineering, 2nd edition. *Collin, Robert E.*, McGraw-Hill, New York, 1992, 924 pp., $65.95.

Microsoft C/C++ Run-Time Library Reference, 2nd edition (Version 7). *Burt, Chris, et al.*, Microsoft Press, New York, 1992, 944 pp., $29.95.

High-Level Synthesis: Introduction to Chip and System Design. *Gajski, Daniel, et al.*, Kluwer Academic, Norwell, Mass., 1992, 359 pp., $80.

Microsoft Word For the Macintosh, Version 5. *Microsoft*, Microsoft Press, Redmond, Wash., 1992, 256 pp., $29.95.

Microcomputer Products Handbook. *Intel*, Intel, Mount Prospect, Ill., 1992, 944 pp., $20.95.

Testing Very Big Systems. *Marks, David M.*, McGraw-Hill, New York, 1992, 188 pp., $34.95.

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Scientific Literacy and the Myth of the Scientific Method. *Bauer, Henry H.*, University of Illinois Press, Champaign, 1992, 180 pp., $24.95.

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Process Improvement in the Electronics Industry. *Fasser, Yefim*, and *Brettner, Donald*, John Wiley & Sons, Somerset, N.J., 1992, 525 pp., $64.95.

Batch Files to Go: A Programmer's Library. *Richardson, Ronny*, Windcrest/McGraw-Hill, Blue Ridge Summit, Pa., 1992, 327 pp., $34.95.

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Computer Professional's Quick Reference. *Vassiliou, M.S., et al.*, McGraw-Hill, New York, 1992, 266 pp., $34.95 (hardcover), $24.95 (paperback).

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Academic Positions Open

Telecommunications: The University of Southwestern Louisiana (USL) is seeking applications for a senior engineering faculty member and a second tenure-track faculty position for their telecommunications program. The senior individual's primary mission is to develop the research stem of our new (Fall 91) graduate program. Both faculty members will be a part of USL's Center for Telecommunications Studies (CTS). CTS is the umbrella organization which coordinates the University's research, undergraduate, graduate and continuing education activities in telecommunications. The telecom option of the BSEE is an ABET accredited program that includes additional courses in the development of the industry and in management. It has graduated over 200 students since its inception in 1982. The current Telecom Option enrollment is 130 students out of 375 enrolled in the Electrical & Computer Engineering (EECE) Department. The MS in Telecommunications is an interdisciplinary program encompassing system engineering, system management and public policy. The University has submitted a letter of intent to offer a PhD in telecommunications to the Louisiana Board of Regents. USL also offers the MS and PhD in Computer Engineering and in Computer Science. The Department of Electrical and Computer Engineering has 14 full time faculty, 6 of whom are in telecommunications. The telecommunications laboratory has a digital switch for a small central office, two Local Area Networks for student experiments, two digital PBX's, two satellite modems for a simulated link, a terrestrial microwave link, and peripheral equipment. The university is well equipped with computers from networked PCs to workstations and an IBM 3090 with vector processor. Faculty divide their time between teaching, research and service to the profession as appropriate. The senior faculty member's duties will be primarily the development of our research program. Thus the individual should have an established record of research and publications. The other position is for a faculty member who will contribute to both the undergraduate and graduate programs. A strong relationship with industry is maintained through the INdustry Telecommunications Advisory Committee (INTAC). Current membership includes 37 individuals representing major corporations nationwide. To date the program has received over one million dollars in scholarships, equipment funds and grants. The state regulations require new engineering faculty to become registered Professional Engineers (PE) before tenure can be granted. Therefore, preference is given to PEs, EITs and those with ABET accredited degrees in addition to the PhD or equivalent. Salaries are commensurate with experience. One position is available in January 1993. We anticipate the senior position to be available for August of that year, pending budgetary approval. Applications will be accepted until the positions are filled. Apply to: Chairman, Faculty Search Committee, Electrical and Computer Engineering, University of Southwestern Louisiana, P.O. Box 43890, Lafayette, LA 70504-3890. 318/231-6568.

Brigham Young University, Computer Science Department, Assistant Professor - Applications are invited for an Assistant Professor position beginning September, 1993. Applicant must have a PhD and should have strong research orientation and scholarly ability. Current areas of research in our PhD and MS programs include User Interfaces, Neural Networks, MultiMedia, Communications/Networking, Software Engineering, Robotics, and Computer Vision. The Computer Science Department is housed in a new 54,000 square foot facility with well equipped teaching and research laboratories. Applicants should send a curriculum vita to E. Daniel Johnson, 3362 TMCB, Brigham Young University, Provo, Utah 84602. BYU is an EEO/AA employer and is sponsored by the Church of Jesus Christ of Latter Day Saints. Preference is given to LDS applicants.

Associate Director, Microelectronics Research Center, Associate Professor of Electrical Engineering, University of Idaho, Vacancy Announcement - University of Idaho. The Department of Electrical Engineering invites applications and nominations for Associate Professor of electrical engineering and Associate Director of the Microelectronics Research Center (MRC). This is a full-time, nine-month , tenured position. The individual sought must have a doctoral degree in electrical engineering or closely related field, an established reputation in electrical or computer engineering, administrative ability, a proven research record of publication and funding, be an excellent teacher and a U.S. citizen or permanent resident. The successful candidate will assist the Director of the MRC in the administration and development of the center and will have teaching and research responsibilities in the Department of Electrical Engineering. The MRC is one of several research centers supported by the University of Idaho. The mission of the MRC is to expand the capabilities of electronic technology by specializing in the design of high-performance computer chips. A major branch of the MRC is the National Aeronautics and Space Administration-funded Space Engineering Research Center (SERC) for VLSI system design, one of nine original SERC's established by NASA in 1988. The Department of Electrical Engineering has programs in electrical and computer engineering with 400 undergraduate students, 50 full-time graduate students and 18 faculty. The main university campus is in Moscow, Idaho, the heart of the scenic intermountain northwest and about 10 miles from Washington State University. About 10,000 students are enrolled on the Moscow campus. Branch campuses are located in Boise and Idaho Falls. Letters of nomination and applications (including three references) should be sent to Dr. Joseph J. Feeley, Chair, Electrical Engineering Department, University of Idaho, Moscow, ID 83843. Search and selection procedures will be closed when a sufficient number of qualified candidates has been identified, but not earlier than December 15, 1992. The University of Idaho is an equal opportunity/affirmative action employer and educational institution.

Director, Microelectronics Research Center, Professor of Electrical Engineering, University of Idaho, Vacancy Announcement - University of Idaho. The Department of Electrical Engineering invites applications and nominations for the position of Professor of Electrical Engineering and Director of the Microelectronics Research Center (MRC). This is a full-time, twelve-month, tenure position. The individual sought must have a doctoral degree in electrical engineering or closely related field, an established reputation in electrical or computer engineering, demonstrated administrative ability, a proven research record of publication and funding, be an excellent teacher and a U.S. citizen or permanent resident. The successful candidate will be responsible for the administration and development of the MRC and will have teaching and research responsibilities in the department of electrical engineering. The MRC is one of several research centers supported by the University of Idaho. The mission of the MRC is to expand the capabilities of electronic technology by specializing in the design of high-performance computer chips. A major branch of the MRC is the National Aeronautics and Space Administration-funded Space Engineering Research Center (SERC) for VLSI system design, one of nine original SERC's established by NASA in 1988. The Department of Electrical Engineering has programs in electrical and computer engineering with 400 undergraduate students, 50 full-time graduate students and 18 faculty. The main university campus is in Moscow, Idaho, the heart of the scenic intermountain northwest and about 10 miles from Washington State University. About 10,000 students are enrolled on the Moscow campus. Branch campuses are located in Boise and Idaho Falls. Letters of nomination and applications (including three references) should be sent to Dr. Joseph J. Feeley, Chair, Electrical Engineering Department, University of Idaho, Moscow, ID 83843. Search and selection procedures will be closed when a sufficient number of qualified candidates has been identified, but not earlier than December 15, 1992. The University of Idaho is an equal opportunity/affirmative action employer and educational institution.

The Bradley Department of Electrical Engineering of Virginia Polytechnic Institute and State University (Virginia Tech) invites applications for tenure track faculty positions at all levels. Needs are in the areas of: (1) thin film devices, including high temperature superconductors and optical devices, and epitaxial device analysis, design, fabrication, and processing; (2) analog circuitry with emphasis on analog VLSI design, analog signal processing, and high frequency techniques. Applicants must have an earned doctorate in Electrical Engineering, be interested in undergraduate and graduate teaching, and be willing to secure research sponsorship. A background of research leadership and international prominence is expected of any senior level applicant. Virginia Tech is Virginia's land grant university offering degrees through the Ph.D. Send complete resume with references and employment/citizenship status to: Prof. Gary S. Brown, Search Committee, Bradley Department of Electrical Engineering, Virginia Tech, Blacksburg, VA 24061-0111. Applications will be accepted until February 15, 1993, or until suitable candidates are selected. Virginia Tech is an Equal Opportunity/Affirmative Action Employer and welcomes applications from minorities and women.

Distinguished Professorship in Power Engineering. The Department of Electrical & Computer Engineering Department at Clemson University invites applications and nominations for the Duke Power Distinguished Professor of Electrical & Computer Engineering. Appointment will be at the rank of tenured Professor. The Duke Power Professor is expected to teach and lead sponsored research programs in electric power systems. Candidates must have a Ph.D. in Electrical Engineering, a demonstrated record of teaching graduate and undergraduate courses, and an outstanding record of research and publishing in the area of electric power systems. The Electrical & Computer Engineering Department has 37 full time faculty members and 195 full-time graduate students. It offers B.S., M.S., and Ph.D. in both Electrical Engineering and Computer Engineering. The power systems focus area is one of the strongest academic programs on campus and is well supported by the power industry through the Clemson University Electric Power Research Association (CUEPRA). In addition to power systems, the Department has

active research programs in communication/ digital signal processing, computer communications, computer systems architecture, controls/ robotics, electromagnetics, and microelectronics. The Clemson College of Engineering's graduate program was listed as one of the nation's "up-and-coming" graduate programs in the March 19, 1990, issue of U.S. News and World Report. Nominations and applications with a resume and a list of references should be sent to Dr. John N. Gowdy, Chairman Duke Pow er Professor Search Committee, Clemson University, Electrical & Computer Engineering Dept., 205 Riggs Hall, Box 340915, Clemson, SC 29634-0915. All applications received by January 1, 1993, will receive full consideration. The search will continue until the Professorship is filled. Clemson is the land-grant university for South Carolina and is located in the state's scenic Piedmont region. The quality of life stems from the four-season climate; the nearby lakes, rivers, and mountains; the reasonable cost of housing and living expenses; and the thriving metropolitan area of Greenville, approximately thirty miles from campus and ranked by Inc. Magazine as one of the twenty fastest growing markets in the country. Clemson University is an Equal Opportunity/ Affirmative Action Employer.

Endowed Chair. Texas A&M University invites nominations and applications for an endowed faculty position in the Electrical Engineering Department in the area of Computer Engineering. The endowment is approximately $2,000,000. Candidates should have outstanding personal and professional qualifications, including international recognition for research contributions. Individuals from academic, industrial, and government research backgrounds are invited to apply. The successful candidate will be expected to provide leadership in both research and teaching and to participate in the development and coordination of programs in the Computer Engineering Group within the Department and in cooperation with the Computer Science Department. The group presently consists of approximately 10 faculty members. The Electrical Engineering Department has about 1200 undergraduate students, 450 graduate students, and a faculty of 49. The active areas of research include digital and analog microelectronics, electronic and magnetic materials and devices, electromagnetics, microwave engineering, computer engineering, electro-optics, controls, telecommunications, and power systems and power electronics. The closing date for this announcement is December 31, 1992. Nominations and applications should be submitted to Dr. Henry F. Taylor, Chairman, Electrical Engineering Chair Search Committee, Department of Electrical Engineering, Texas A&M University, College Station, Texas 77843, (409) 845-7441. Texas A&M University of an affirmative action equal opportunity employer.

Chairperson, Electrical Engineering, Case Western Reserve University. Nominations and applications are sought for the chair position to begin Fall 1993 at the rank of full professor. Required qualifications include: notable achievements in teaching and research in areas relevant to the department; accomplishments in professional practice; involvement in professional societies; and an understanding of academic administration at the departmental level. One of nine departments in the Case School of Engineering, Electrical Engineering and Applied Physics currently enrolls 150 undergraduate and 90 graduate students. Increasing enrollments in the Case School of Engineering provide opportunities for departmental expansion in both its academic and research programs. External research funding includes the areas of solid state transducers and semiconductor devices, intelligent systems, robotics and control. There is significant research interaction with the allied departments of Computer Engineering and Science, Systems Engineering, Materials Science and Engineering, Biomedical Engineering as well as with five cross disciplinary research Centers. Nominations and applications (with Curricula Vitae and three references who may be contacted) as well as further inquiries should be sent to Professor Robert E. Collin, Chair, Search Committee, Dept. of Electrical Engineering and Applied Physics, CWRU, 10900 Euclid Avenue, Cleveland, OH 44106. (Tel. No. (216) 368-6437). Nominations and applications received by Feb. 1, 1993 will be assured of consideration. Case Western Reserve University is an affirmative action/equal opportunity employer. Women and minority candidates are encouraged to apply.

University of California, Santa Cruz invites applications for a position as Assistant (#141-889). Associate or Full Professor (141-0 00) in Computer Engineering, in the areas of imaging/ image processing/image systems, as well as workstation interfaces, networking and multimedia database systems. See advertisement in the October issue of Spectrum, for details, or write to: Chair, Computer Engineering Faculty Search Committee, 225 Applied Sciences, University of California, Santa Cruz, CA 95064. (Questions may be sent via email to recruit@csc.ucsc.edu or recruit@ucsccrls.bitnet.) Closing date: February 1, 1993. UCSC is an EEO/AA/IRCA employer.

Department of Electrical Engineering, University of Missouri-Rolla - Employment Opportunity Advertisement - Tenure Track Assistant Professor Position. University of Missouri-Rolla seeks applicants for 1993 tenure track assistant professor (PhD required) position. Only applicants in power engineering or electrical machinery will be considered. Permanent residency or U.S. citizenship is essential at the time of employment. Please send resume and the names of three references to: W.J. Gajda, Jr., Chairman, Department of Electrical Engineering, University of Missouri-Rolla, Rolla, MO 65401. Application deadline is January 31, 1993. The University of Missouri is an Equal Opportunity/Affirmative Action employer.

Columbia University. The Department of Electrical Engineering invites applicants for a tenure-track faculty position. Exceptional candidates are sought to fill a potential position in software for telecommunications. A successful candidate is expected to establish a strong research program and have a desire to teach at both the undergraduate and graduate levels. Applicants should have expertise in areas such as object oriented operating systems and databases, data and knowledge engineering, or parallel and distributed systems, with a view toward applications in network management and control or high speed protocols. Research would be conducted within the laboratories of the Center for Telecommunications Research (CTR) a national Engineering Research Center. The CTR is a leading edge interdisciplinary research facility emphasizing network management and control, high speed optical networks, and broadband applications such as multimedia communication, wireless personal communication systems, and HDTV. Please send your resume and the names of three references to: Professor T.E. Stern, Chairman, Department of Electrical Engineering, Columbia University, 500 West 120th Street, Room 1312, New York, NY 10027. Columbia is an equal opportunity/affirmative action employer.

Columbia University Department of Electrical Engineering has a tenure track opening at the assistant professor level for an exceptional candidate in experimental optoelectronics and microelectronics. Experience is required in small dimension device fabrication using dry processing. Responsibilities include guidance of undergraduate laboratories, teaching, and initiation of a strong research program. Please send your resume and names of three references to: Professor Thomas E. Stern, Chairman, Department of Electrical Engineering, 500 West 120th Street, Columbia University, New York, NY 10027. Columbia University is an equal opportunity/affirmative action employer.

Faculty Positions - Massachusetts Institute of Technology. The Department of Electrical Engineering and Computer Science seeks candidates for faculty positions starting in September 1993. We anticipate openings for several junior faculty appointments for individuals who are completing, or who have recently completed, a doctorate. Senior faculty positions may also be available in some areas. Faculty duties include teaching at both the graduate and undergraduate levels, research, and supervision of theses. We are interested in candidates in most areas of electrical engineering and computer science. All candidates should write to the address below, describing their professional interests and goals. Each application should include a curriculum vitae and the names and addresses of three or more references. Additional material describing the applicant's work, such as papers or technical reports, would also be helpful. All candidates should indicate citizenship and, in the case of non-US citizens, describe their visa status. Send all applications to: Prof. F.C. Hennie, Room 38-435, Massachusetts Institute of Technology, Cambridge, MA 02139. M.I.T. is an equal opportunity/affirmative action employer.

The University of Florida, Department of Electrical Engineering, is seeking individuals to fill three junior faculty positions in the following areas: solid-state electronic circuits, systems and controls, communications, and computer engineering/digital signal processing. The positions are tenure track beginning in the Fall of 1993. Candidates are required to have a Ph.D. in an area related to the field. Potential faculty members are expected to develop a program of funded research in the area of their expertise as well as teach in that area. The University of Florida is an Affirmative Action Employer and women and minorities are encouraged to apply. According to Florida law, applications and meetings regarding applications are open to the public upon request. Please send application to Dr. M.A. Uman, Chairman, Department of Electrical Engineering, 216 Larsen Hall, University of Florida, Gainesville, Florida 32611. Applications must be received by February 1, 1993.

Carnegie Mellon. Graduate Study in Engineering and Public Policy (EPP) leads to a research-based Ph.D. specializing in policy issues in areas such as: telecommunication, computer and other information technologies; energy and environmental systems (including climate change); technical issues in international security; manufacturing and industrial policy; and risk analysis. Applicants must hold BA or BS in engineering, physical sciences, or math. Education or experience beyond the BS very desirable. Contact Denise Murrin-Macey, Engineering and Public Policy (06), Carnegie Mellon, Pittsburgh, PA 15213.

Concordia University - Electrical and Computer Engineering. The Department of Electrical and Computer Engineering at Concordia University invites applications for a full-time, tenure track faculty position at the senior level in the area of Power Electronics. Candidates should have considerable experience in the analysis and design of static power converter systems using modern topologies and control techniques. Industrial experience in modern power converter systems design and development is considered very important. Responsibilities include graduate and undergraduate teaching, research and supervision of graduate students. Candidates should have a Ph.D. in Electrical Engineering and a demonstrated interest in both research and teaching. The department currently has 24 full-time faculty members and is strongly committed to research excellence. It offers bachelor's programs in Electrical Engineering and Computer Engineering, and Master's and Doctoral programs in Electrical Engineering. There are currently over 150 graduate students, of whom approximately 50 are doctoral students. In accordance with Canadian Immigration requirements, priority will be given to citizens and permanent residents of Canada. Concordia University is committed to employment equity and encourages applications from women, aboriginal people, visible minorities and disabled persons. All things being equal, women candidates shall be given priority. Applications will be accepted until the position is filled. Applicants should send a resume and names of at least three references to: Dr. J.C. Giguere, Acting Chair, Department of Electrical and Computer Engineering, Concordia University, 1455 de Maisonneuve Blvd., West, Montreal, Quebec, H3G 1M8, Canada. Fax: (514) 848-2802.

Faculty Positions, City College of New York. The Department of Electrical Engineering at the City College of the City University of New York is seeking to fill several tenure-track faculty positions. Applicants must possess a Ph.D., outstanding academic credentials and a strong commitment to teaching and research. Candidates must demonstrate interest and experience in at least one of the following areas: Computer Engineering; Communications; Microwaves;

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Signal Processing; Control Systems; Image Processing. An outstanding research reputation, with the ability to attract external funding, for senior positions, or a demonstrated research potential, for junior positions, is desirable. Resumes, including recent publications and research interest, names of three professional references should be sent to: Chair, Department of Electrical Engineering, The City College of CUNY, Convent Ave. & 138th Street, New York, NY 10031. Deadline for applications is January 31, 1993 or until all positions are filled. An AA/EO Employer M/F.

The Johns Hopkins University, Department of Electrical and Computer Engineering, invites applications for tenure-track faculty positions at the assistant or associate professor level in the areas of computer engineering, communications, and signal/image processing. Candidates for associate professor appointments are expected to have significant research records. Candidates for assistant professor appointments are expected to show strong research potential. Applicants should send resumes, including names of at least three references, to Search Committee, Department of Electrical and Computer Engineering, The Johns Hopkins University, Baltimore, MD 21218-2868. Resumes may also be faxed to (410) 516-5566. The Johns Hopkins University is an equal opportunity/affirmative action employer.

Tennessee Technological University - Department of Electrical Engineering invites applications for a tenure-track faculty position. The individual should have expertise in digital design with desirable experience in VLSI and electronics. Candidates must have a Ph.D. in electrical or electrical and computer engineering and must have high potential for excellent teaching at the undergraduate and graduate levels and conducting externally funded research. The EE Department with about 300 undergraduate, 45 M.S. and 19 Ph.D. students and 20 faculty members provides an exciting environment for beginning educators to grow and excel in their profession. Three state-supported Centers of Excellence within the College of Engineering support and promote research of the faculty and graduate students. Salary and rank are negotiable; however, preference will be given to the rank of assistant professor. Screening of applications will begin by February 1, 1993 and continue until the position is filled. Submit resume and three references to Dr. Homer Powell, Chairperson, Faculty Search Committee, Box 5004, Electrical Engineering Department, Tennessee Technological University, Cookeville, TN 38505. TTU is an affirmative action/equal employment opportunity/ADA employer.

San Jose State University, Electrical Engineering Department - Applications are invited for tenure-track faculty positions. Assistant Professor applicants are particularly encouraged to apply. Positions are available in microelectronic VLSI/ULSI circuit design, semiconductor devices and technologies; circuits, systems and computer communications networks; computer and multiprocessor design, microprocessor applications. Earned doctorate in Electrical Engineering is required. Positions are limited to U.S. citizens or permanent residents. Research, consulting and summer employment opportunities are available. The University is the oldest and one of the largest in the California State University System. It is located at the southern end of San Francisco Bay in the heart of Silicon Valley. Resume and names and addresses of three references should be submitted to Dr. Ray R. Chen, Chair, Department of Electrical Engineering, San Jose State University, San Jose, CA 95192-0084. San Jose State University is an equal opportunity/affirmative action/Title IX employer. Women and minorities are especially encouraged to apply.

University of South Australia - Professor of Computer & Information Science, Professor of Computer Systems Engineering. Applications are invited for appointment to a Chair in Computer and Information Science, and/or to the Foundation Chair in Computer Systems Engineering. These positions are located at the Levels Campus in Adelaide. The former position is located within the School of Computer and Information Science; the latter is a joint appointment in that School and the School of Electronic Engineering. An appointee as Professor is expected to provide strong academic leadership in research and scholarship, and to seek significant external research support. A PhD or equivalent qualification in an appropriate discipline is essential, as are the ability to generate research ideas and a capacity for creative research. The Computer Systems Engineering position requires a person who is a professional engineer, with strong interests also in computer science/software engineering. The School of Electronic Engineering has established a strong and unique research record in selected areas of electronic engineering including digital communications, microelectronics, and measurement and instrumentation. The School of Computer and Information Science has research groups in database systems, decision support systems and complex software systems. Interaction with industry provides excellent opportunities for collaborative research and consultancy. Both Schools have well equipped laboratory facilities and a wide range of computing facilities. The salary for a Professor is A$77,900 per annum. Opportunities for private consulting enable the salary to be augmented. An Information Package about the positions, including role statements, must be obtained from Prof. R.S. Northcote, Dean, Faculty of Applied Science and Technology, Tel: +61 8 302 3202, Fax +61 8 302 3390, email: Bob.Northcote@UniSA.Edu.Au prior to submitting an application. Applications, which address the essential criteria specified on the role statement in the Information Package, close on 30 January 1993. A suitably qualified applicant may apply for both positions. Previous applicants for the Chair in Computer Systems Engineering may re-apply. The University reserves the right to appoint by invitation, not to make an appointment, or to offer appointment at the level of Associate Professor. The University is an Equal Opportunity Employer.

Lecturer-Tenurable, School of Electrical Engineering. The University of Technology, Sydney invites applications for this position. The appointee will join one of two discipline groups - Telecommunications or Instrumentation and Control. An ability to lead the School's teaching effort in one or more of the following areas is essential: Control-data acquisition and instrumentation systems, multivariable and adaptive control, intelligent sensors, analogue and digital electronics or mechatronics; Telecommunications-communication networks, digital transmission or signal processing. The appointee will typically be a recent Phd in Electrical Engineering or be nearing completion of a Phd. Desirably the candidate will have significant industrial experience either at pre or post doctoral level, and will be expected to participate in one of the School's existing research initiatives, which include; robotics, biomedical engineering, distributed multimedia systems, ultrasonic distant measurement, mobile and satellite communications and image processing. Enquiries to Professor Warren Yates on (0011 61 2) 330.2436 or fax (0011 61 2) 330.2435, email warren @ee.uts.edu.au. Salary Range: $41,000-$48,688 p.a. Appointment will be made up to the middle of the salary range. Membership of a University approved superannuation scheme is compulsory for new appointees. Position criteria can be obtained by telephoning (0011 61 2) 330.1087. Applications should be forwarded to: The Recruitment Co-Ordinator, University of Technology Sydney, PO Box 123, Sydney NSW 2007, Australia, quoting Ref No. E150/49 and include telephone and fax nos of three referees. Closing date 30 January, 1993.

Christchurch, New Zealand - University of Canterbury. Lecturer in Electrical and Electronic Engineering. Applicants should have a proven research record, demonstrable ability in teaching and specialist knowledge in at least one of the following: industrial control; power electronics; electrical machines; integrated circuit design. An extremely strong candidate in other related fields may be considered for the position. Applicants should have a doctorate, several refereed publications and preferably some industrial or consulting experience. The duties of Lecturer include the teaching of undergraduate courses, undertaking of research and supervision of research students. The salary for Lecturers is on a scale from NZ$37,440 to NZ$45,448 (bar), and from NZ$46,800 to NZ$49,088 per annum. Applications close on 29 January 1993. Further particulars and Conditions of Appointment may be obtained from the undersigned. Applications, quoting Position No. EE32, must be addressed to: Mr. A.W. Hayward, Registrar, University of Canterbury, Private Bag 4800, Christchurch, New Zealand. The University has a policy of equality of opportunity in employment.

Head, Department of Electrical Engineering. The Virginia Military Institute (VMI) seeks qualified applicants. Candidates should have the PhD in Electrical Engineering and have a strong background and interest in teaching. VMI is a four year undergraduate military college that supports research. Being a military college all new faculty are required to wear a military uniform. In addition to administrative duties the department head teaches half time in a department of 90 undergraduates and seven faculty. In order to be appointed at the associate or full professor level the applicant must possess or take the necessary steps to obtain, within reasonable time, a professional engineering (PE) registration. The appointment is a nine month (tenure track), position starting August 1, 1993. Send resume, names and addresses of three references, and detailed description of teaching interests to Dr. G.G. Balazs, Chair, Search Committee, Department of Electrical Engineering, Virginia Military Institute, Lexington, VA 24450. Closing date will be February 1, 1993, or thereafter until position is filled. The VMI is an AA/EEO employer.

Two Faculty Positions: The Division of Engineering at the University of Texas at San Antonio invites applications for two tenure-track Assistant Professor positions in Electrical Engineering. Ph.D. degree required. Successful candidates are expected to participate in both undergraduate and graduate teaching, and in research activities. The first position is in the area of communications engineering with an emphasis on telecommunications. The second position is in the area of computer engineering with an emphasis on distributed and parallel processing and fault tolerant computing. Candidates with background in these areas will be given preference, but applicants with background in the areas of digital systems, microelectronics, and VLSI will also be considered. Salary commensurate with qualifications and experience. UTSA is a comprehensive metropolitan university located on the edge of the Texas Hill Country. San Antonio combines a rich cultural heritage with a modern focus on education, research, and technology. Send resume and names, addresses, and phone numbers of four references by January 31, 1993 to: Chair (EE-4), Electrical Engineering Search Committee, Division of Engineering, The University of Texas at San Antonio, San Antonio, Texas 78249-0665. UTSA is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

The University of Missouri-Columbia Department of Electrical and Computer Engineering invites applications for a tenure-track position at the assistant professor level in the area of computer engineering. Responsibilities include teaching undergraduate and graduate courses, student advising and developing and conducting sponsored research programs. Candidates must have an earned doctorate in Electrical or Computer Engineering, Computer Science or related discipline, and the potential for, and commitment to, developing sponsored research. The department is looking for a candidate with an interest and background in the general area of computer systems to complement our strong program in computer vision, fuzzy logic, pattern-recognition, neural networks, and artificial intelligence. Preference will be given to candidates with specialization in computer architecture or parallel and distributed computing. Interested applicants should send a resume, a description of research interests, and immigration status for non-United States citizen to: Jon Meese, Chairman, Department of Electrical and Computer Engineering,

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University of California, Santa Barbara, Electrical and Computer Engineering. Applications are invited for two tenure-track assistant professor positions, available effective 7/1/93. One position is in the area of massively parallel algorithms (with applications in control, communications, or signal processing). The other position (higher level appointment is possible for outstanding individuals) is in the area of computer engineering, preferably in computer architectures, digital design, and VLSI testing. Normally, completion of a doctorate is required at the time of the appointment. Candidates should have an established research reputation or outstanding research potential, the ability to attract external research funding, and a strong commitment to teaching at the undergraduate and graduate levels. Applicants should send their resumes and the names and addresses of at least four professional references to: Faculty Search Committee, Department of Electrical and Computer Engineering, University of California, Santa Barbara, CA 93106-9560. Applications will be received until the positions are filled. UCSB is an Equal Opportunity/Affirmative Action employer.

Computer Engineering Department, San Jose State University, invites applications for tenure track faculty positions. Earned doctorate in Computer Engineering or Electrical Engineering with emphasis in computer hardware and software design is required. Positions are limited to US Citizens or Permanent Residents. The major goals are graduate course development and establishment of a research program. Three or more years of relevant industrial experience are desirable. Rank and salary consistent with qualifications and experience. Open period is from 11-1-92 until positions are filled. Please send a letter of intent explicitly stating your area(s) of interest, a copy of your most significant peer reviewed publication (or a significant abstract of your recently completed Dissertation) related to your area(s) of interest, a complete curriculum vitae, and names and telephone numbers of three references to Dr. Nicholas L. Pappas, Chair, Computer Engineering Department, San Jose University, San Jose, CA 95192-0085. SJSU is an equal opportunity, affirmative action, Title IX employer.

The Department of Electrical and Computer Engineering, The University of Texas at Austin, invites applications for tenure-track positions at the assistant professor level, particularly in the areas of computer engineering, software engineering, energy systems, informations systems, telecommunications and related areas. Applicants must demonstrate exceptional teaching ability and research potential. Excellent English communication skills are required. Applicants, who do not hold a Ph.D., must be making satisfactory progress toward a Ph.D. or equivalent in electrical engineering, computer engineering or a related area, with a reasonable expectation of completion by August 31, 1993. Successful candidates are expected to pursue an active research program, perform both undergraduate and graduate teaching, and supervise graduate students. Priority will be given to applications received by March 1, 1993. Send letter of application, vita, and a list of addresses for at least three references to the following address: Dr. Mario Gonzalez, Chairman, Department of Electrical and Computer Engineering, The University of Texas at Austin, Austin, TX 78712-1084.

Electrical Engineering: The Department of Electrical Engineering at Memphis State University is now accepting applications for tenure-track faculty positions. Preference will be given to applicants for the Assistant or Associate Professor level. Applicants with research specializations in computer engineering, biomedical engineering, communications, power or electro-optics are preferred. Candidates should be available for employment by August 20, 1993. Research experience and potential for securing funded research will be important considerations in candidate selection. An earned doctorate in electrical engineering or related area is required. Interested applicants should send resumes with names, addresses, and telephone numbers of three references to: Dr. Carl E. Halford, Department of Electrical Engineering, Memphis State University, Memphis, TN 38152. Closing date for applications is January 29, 1993, with initial screening to begin at that time. However, if needed, applications will be reviewed until positions are filled. Equal opportunity, affirmative action employer. Successful candidates must meet Immigration Reform Act criteria.

The University of Maryland at College Park Electrical Engineering Department expects to have openings for regular faculty positions effective with the start of the 1993-94 academic year. Applicants at all ranks will be considered. Candidates for the rank of Assistant Professor should have a high potential for both teaching and research. Candidates for the rank of Associate and Full Professor should have distinguished records in research and a strong interest in educational programs. The Department conducts strong research and educational programs in information science and systems, including controls, communications and computer engineering, and in electronic science and devices, including microelectronics, optoelectronics, and electrophysics. Candidates in any of these areas will be considered. Applications, including resume, list of publications, list of references, and identification of technical area in which the candidate wishes to be considered, should be sent to Dr. William W. Destler, Chairman, Electrical Engineering Department, University of Maryland at College Park, College Park, MD 20742. The University of Maryland is an equal opportunity, affirmative action employer.

Concordia University, Department of Electrical and Computer Engineering - The Department of Electrical and Computer Engineering invites applications for a tenure-track faculty position at the assistant/associate professor level. The position is in the area of analog electronics. The applicant must have a strong background in analog integrated circuit design with emphasis on current-mode techniques. The applicant must also be well-versed with the recent advances in the integrated circuit technologies such as complementary bipolar, CMOS VLSI, and gallium arsenide processings. Responsibilities include graduate and undergraduate teaching, research, and supervision of graduate students in the above area. The candidate should have a Ph.D. in Electrical Engineering and a strong interest in both research and teaching. The department currently has 24 full-time faculty members and is strongly committed to research excellence. The department offers Bachelor's programs in Electrical Engineering and Computer Engineering, and Master's and Doctoral programs in Electrical Engineering. There are currently over 450 undergraduate and 150 graduate students of whom approximately 50 are doctoral students. The department has a state-of-the-art VLSI circuit design laboratory. In accordance with Canadian Immigration requirements, priority will be given to citizens and permanent residents of Canada. Concordia University is committed to employment equity and encourages applications from women, aboriginal people, visible minorities and disabled persons. All things being equal, women candidates shall be given priority. Applications will be accepted until the position is filled. Applicants should send a resume and the names of at least three references to: Dr. J.C. Giguere, Acting Chair, Department of Electrical and Computer Engineering, Concordia University, 1455 de Maisonneuve Blvd., West, Montreal, Quebec, H3G 1M8, Canada. Fax: 514-848-2802.

State University of New York at Buffalo - The Department of Electrical and Computer Engineering invites applications for three anticipated faculty positions for September 1993/94. One visiting position is in the areas of solid state lasers and materials, photonics, integrated optics, optical communications, and optoelectronics. Two tenure-track or tenured positions are in the areas of computer arithmetic and its algorithmic and device aspects, VLSI design and applications, communications, signal and image processing. Send resume and names of four references to Prof. Adly T. Fam, Department of Electrical and Computer Engineering, State University of New York, Buffalo, NY 14260. Affirmative Action, Equal Opportunity Employer.

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Assistant/Associate Professor - Electrical Engineering. The Electrical Engineering Department at The Wichita State University is seeking applications for a tenure eligible Assistant/Associate Professor position in Electrical Engineering. (The offering of this position is conditional upon the availability of the required funds.) The position requires specialization in the area of communications preferably telecommunicaions. The successful applicants will be required to teach at the Undergraduate and Graduate level, to conduct research, and to publish the results of that research in appropriate journals. Service in the form of student advising and committee participation is required. A terminal degree in Electrical Engineering is required. The applicant must be a United States citizen or have permanent resident status and be eligible to obtain professional engineering registration in the State of Kansas. The salary is commensurate with qualifications. The first application deadline is 1-31-93. If the position is not filled from this first pool of applicants, applicants will be reviewed at the end of each month until the position is filled. The final deadline for applications will be 5-15-93. Send applications with resumes to: Dr. Roy H. Norris, Electrical Engineering, The Wichita State University, 1845 Fairmount, Wichita, Kansas 67260-0044. The Wichita State University is an Equal Opportunity/Affirmative Action Employer.

University of Illinois at Chicago. Instructorships and tenure-track faculty positions in electrical engineering and computer science at both the junior and senior levels are available. Rank and salary commensurate with qualifications. An earned Doctorate in EE or CS must be completed by date of appointment, but not for the instructorships. Demonstrated teaching and research abilities are highly desirable. For full consideration, please send resume, list of publications, and the names of at least three references by March 30, 1993, to Dr. Wai-Kai Chen, Head, Department of Electrical Engineering and Computer Science (M/C 154), University of Illinois at Chicago, P.O. Box 4348, Chicago, Illinois 60680. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

Stanford University: The Design Division of the Mechanical Engineering Department invites applications for a tenure-track Assistant Professor position in programmable-electro-mechanical-systems design. The successful candidate will be expected to lead Stanford's "smart product design" curriculum (Mechatronics). Industrial experience is desirable. A research program is essential. Please send a letter of introduction, resume and exemplary material to Professor Bernard Roth, Design Division, Mechanical Engineering, Stanford University, Stanford, CA 94305-4021. Stanford is an equal opportunity/affirmative action employer.

Chairperson, Department of Electrical Engineering, Florida Atlantic University. The College of Engineering at Florida Atlantic University invites applications and nominations for the position of Chairperson, Department of Electrical Engineering. The position is for a tenured appointment at the rank of Professor in the Department of Electrical Engineering. Qualified applicants must possess an earned doctorate in

Electrical Engineering or a closely related field, be prominent researchers with a proven record of publications in reputable journals, have excellent leadership skills, administrative and teaching experience. Of special consideration will be the chairperson's demonstrated ability in attracting sponsored research and willingness to work closely with a diverse community of scholars, industrial corporations, and government agencies. Florida Atlantic University is a member of Florida's State University System and is located in Boca Raton on the Atlantic Ocean. The University has experienced a steady growth in student enrollment which currently stands at about 14,700. The location of the University, in an area of thriving economic activity with an unexcelled quality of life attracts faculty and students from all over the world. The College of Engineering is one of the nine colleges of the University. The college houses four departments: Computer Science and Engineering, Electrical Engineering, Mechanical Engineering, and Ocean Engineering. All departments offer PhD, MS, and BS degrees. The sponsored research expenditure of the college for 1990-1991 exceeded $4.5M and the projected sponsored research for 1991-92 is $6M. The College has close ties with many high-tech industries in the region including IBM, Motorola, Siemens, and Pratt and Whitney. The Department of Electrical Engineering has 17 regular and 4 adjunct faculty members. Research interests of faculty include robotics and control, communications, electromagnetics, and signal processing. Over 460 undergraduate students, 70 master's students, and 25 doctoral students are presently enrolled in the Department. Applications or nominations should include a statement of interest, curriculum vitae, and at least three references. Under the "Florida Sunshine Law" all information furnished in the applications is accessible to the general public. All applications and nominations must be received by February 15, 1993. All correspondence should be addressed to: EE Chair Search Committee, Department of Electrical Engineering, Florida Atlantic University, Boca Raton, Florida 33431. Florida Atlantic University is an equal opportunity/affirmative action employer. Members of protected classes are encouraged to apply.

Electrical Engineering: Bucknell University invites applications for a tenure-track position at the Assistant Professor level. We are seeking an individual with promise as a teacher and researcher. Responsibilities include course and laboratory development and supervision of design projects. Preferred areas are signal processing and communications. A background in optics, optical electronics or optical communications is desirable. Qualifications include a Ph.D. in Electrical Engineering. Bucknell is a private university emphasizing quality undergraduate education in engineering and liberal arts. Review of applications will begin on January 15, 1993 and will continue until the position is filled. Please send applications to: Maurice F. Aburdene, Electrical Engineering Department, Bucknell University, Lewisburg, PA 17837. Women and members of minority groups are especially encouraged to apply.

The Center for Advanced Computer Studies. The Center is seeking highly qualified candidates for tenure track faculty positions in Computer Science and Computer Engineering. Three openings are available: one at each professorial rank beginning Fall 1993. Candidates must hold PhDs in the field and have strong research potential. Senior candidates must have established research and publication records. Consideration will be given to all qualified candidates, but preference areas of interest are: software engineering, programming languages, operating systems, database systems, image processing, computer architecture, and theoretical computer science. The Center conducts programs leading to the MS/PhD degrees in Computer Science and Computer Engineering. These programs currently enroll more than 250 students, including over 100 PhD students. A number of PhD fellowships and assistantships are available, with stipends of up to $18,000 per year, renewable for a maximum of four years. Typical faculty teaching load is two courses per year and a continuing research seminar. Substantial State Educational Fund monies are available to establish research programs. The University is located in Acadiana, about 120 miles west of New Orleans. Send resumes to: Dr. Michael C. Mulder, Director, The Center for Advanced Computer Studies, University of Southwestern Louisiana, P.O. Box 44330, Lafayette, LA 70504. Applications will be considered beginning 1 January 1993 until all positions are filled. The University of Southwestern Louisiana is an affirmative action/equal opportunity employer.

Manager of Technology Development wanted to increase industrial involvement in the Consortium for Commercial Crystal Growth managed by Clarkson University. This is one of 17 Centers for the Commercial Development of Space funded by NASA. Members include Grumman, Teledyne-Brown, Westinghouse, U of Florida, RPI, WPI, NIST and Alabama A&M U. The candidate should have industrial experience in utilization of bulk crystals for electronic, optical or sensor devices. Requires willingness to travel, excellent communication skills. Salary to $60,000 per year. Send resume and three references to W.R. Wilcox, Clarkson University, Potsdam, NY 13699-5700. Phone 315-268-6446; fax 3841; e-mail SOE1@CLVM.CLARKSON.EDU. Search will continue until position is filled, with interviews beginning in December 1992. Clarkson is an affirmative action/equal opportunity employer.

Mercer University School of Engineering invites applications for the following tenure earning positions: Chair, Electrical and Computer Engineering Department - 12 month appointment to begin July 1, 1993. Requires administrative experience and a balanced commitment to excellence in undergraduate and graduate teaching and research. The applicant should have a record of scholarly publications, of attracting external funding, of interaction with industries and governmental agencies, and of active participation in professional organizations. He or she should have excellent interpersonal and communication skills and be an effective leader in guiding the growth and development of the department. Faculty, Electrical and Computer Engineering Department - Position to begin September 1, 1993 requires expertise in the areas of digital signal processing and digital communication or control. Responsibilities include teaching and advising at the undergraduate and graduate levels and normal academic duties. Graduate classes are held in both Warner Robins and Atlanta Georgia, requiring travel. The pursuit of research opportunities and other scholarly activity is expected. Faculty, Computer and Information Systems Department - Position to begin September 1, 1993. Areas include software engineering processes and methodologies, information theory, systems design, AI theory and techniques, networks and embedded systems. Position requires curriculum development, teaching at the graduate and undergraduate levels, advising students, and research. Applicants should have expertise in software engineering, computer science, computer engineering, or a closely related field. All positions require an earned doctorate in the discipline or a closely related field and excellent command of English. Industrial experience and U.S. citizenship preferred. Rank and salary commensurate with experience. Screening of applicants will begin January 1, 1993 and continue until positions are filled. Submit applications, complete resume, and names, addresses and telephone numbers of at least three references to: Office of the Dean, School of Engineering, Mercer University, 1400 Coleman Avenue, Macon, GA 31207. Mercer University is an affirmative action, equal opportunity employer. Minorities and women are encouraged to apply.

The Department of Electrical and Computer Engineering at the University of Missouri-Columbia's Kansas City program invites applications for tenure track positions in Electrical and Computer Engineering at the Assistant, Associate or Full Professor level in the Engineering College's Coordinated Engineering Program (CEP) on the Kansas City campus of the University of Missouri-Kansas City. Faculty in the CEP are University of Missouri-Columbia faculty that reside in the Kansas City area. The CEP is a full-time teaching and research program with 16 faculty members offering ABET accredited B.S. degrees as well as Masters and Ph.D. degrees in Electrical, Mechanical and Civil Engineering. The CEP Electrical Engineering program presently has 160 undergraduates and 65 graduate students pursuing Masters and Ph.D. degrees and an active research program in computers, signal processing, electro-optics and power. Applicants must have an earned Ph.D. in electrical engineering and a proven record of scholarly work in both teaching and research. Responsibilities include teaching engineering courses at all levels (B.S. through Ph.D.), establishing high quality programs in sponsored research, research collaboration with local industry, supervising Master's and Doctoral students and advising students at all levels. Preference will be given to candidates having prior experience in other ABET accredited engineering programs or significant industrial research experience in the following areas: computer engineering, electro-optics, robotics, image processing and VLSI design. Desirable candidates should have either U.S. citizenship or a permanent residency. Applicants should send a resume, a statement of research and teaching interests and three references to Dr. Jerome Knopp, Executive Director CEP, Electrical and Computer Engineering, The University of Missouri-Columbia Truman Campus, 600 W. Mechanic, Independence, Missouri 64050. Candidates are sought for the semester starting January 1993 as well as September 1993. Applications for the January semester will be accepted until January 12, 1993. Candidates for the fall semester will be accepted until February 12, 1993 or until the 12th of each succeeding month until all positions are filled. The University of Missouri is an equal opportunity, affirmative action employer.

University of California, Davis - Faculty Positions in Electrical and Computer Engineering. The Department of Electrical and Computer Engineering at UC Davis invites applications for a tenure track faculty position at the Assistant Professor level. Applicants are sought in the following two areas: (1) computer engineering with speciality in embedded computing systems, hardware/software co-design, and real time operating systems; and (2) optoelectronic devices with particular emphasis in experimental research on compound semiconductor optoelectronic devices and their fabrication. The department, with 34 faculty members and 140 full-time graduate students, is experiencing rapid growth. We have exceptional teaching and research facilities and are preparing to move into a large, new building which is currently in the final stages of construction. Salary and benefits are extremely attractive. Davis is a pleasant, family-oriented community near Sacramento, within easy driving distance to Silicon Valley, the Lawrence Livermore National Laboratory, San Francisco, the Pacific Ocean, and the Sierra Nevada Mountains. We are seeking individuals with strong records in research, with ambitious plans and evidence of great promise. All faculty are expected to have a strong commitment to teaching at all degree levels, and to demonstrate the ability to attract significant research support. The positions require a Ph.D. degree or equivalent, and are open until filled; but in order to assure consideration, applications should be received by April 1, 1993. Send a resume and the names of at least three references to: Professor S. Louis Hakimi, Chair, Attention: Faculty Search Committee, Department of Electrical Engineering and Computer Science, University of California, Davis, CA 95616. The University of California, Davis, is an equal opportunity/affirmative action employer.

Colorado School of Mines - Golden, Colorado - Faculty Position in Engineering - Electrical Engineering Image Processing and Analysis. The Colorado School of Mines is accepting applications for a tenure track faculty position in the Division of Engineering. This Division offers interdisciplinary degree programs in engineering and is oriented toward interdisciplinary engineering research as it relates to the energy, materials and resource industries. Candidates for the position must have a strong background in electrical engineering with research credentials and exper-

tise in digital imaging systems, photonics and optical signal-processing. Further preference will be given to candidates having applications interests in any or several of the following areas: advanced materials diagnostics, non-destructive evaluation techniques, machine vision, flow visualization, and computed imaging. Responsibilities include the development of a funded research program in digital imaging with interdisciplinary applications in energy or materials, teaching at the graduate level in engineering, teaching at the undergraduate level in electrical engineering, and innovation and program development in interdisciplinary engineering education. Candidates must have a doctoral degree in engineering or related area, including at least a baccalaureate degree in electrical engineering, and should have a clear commitment to excellence in engineering education. Preference will be given to candidates who have an established record of scholarly accomplishments and funded research. Application deadline: 31 January, 1993, or until such time as a successful candidate has been identified. Resumes, supporting materials, and the names and addresses of three references should be directed to: Colorado School of Mines, Image Processing & Analysis Search Committee, #9210-27, 1500 Illinois Street, Golden, CO 80401. An equal opportunity/affirmative action employer.

Carnegie Mellon University, Department of Electrical and Computer Engineering is seeking to fill a tenure track faculty position in the computer engineering area. The department prefers to make these appointments at the non-tenured level (assistant or associate professor), but appointment at tenured, full professor level may be considered in exceptional cases. Applicants must have an earned Ph.D. with outstanding academic credentials, a sincere commitment to teaching at both the graduate and undergraduate levels, and the ability to implement an independent research program. Teaching and/or industrial experience is desirable. Carnegie Mellon University is an equal opportunity affirmative action employer and welcomes applications from women and minority groups. Send resume with names of three references, and a list of publications to Professor Donald E. Thomas, Acting Head, Department of Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh, PA 15213. All applications received through March 1, 1993 will receive full consideration; applications received after March 1 may also be considered if the position is not filled.

Associate Director of EIRC and Research Professor of Materials Science - University of Connecticut. The Institute of Materials Science is soliciting applications for the position of Associate Director, Electrical Insulation Research Center, and Research Professor of Materials Science. The candidate must hold a doctorate in a relevant technical discipline and must be able to communicate effectively with constituencies ranging from fellow professors and scientists to utility engineering staff and to field technicians. A broad background and creative accomplishments embracing many disciplines, such as electrical engineering, physics and chemistry, are sought. The candidate must demonstrate expertise in utility-related research through past publications, patents, industry recognition and actual involvement with utilities either as an employee or as a consultant for 10 years or more. In addition to academic capability, the candidate must demonstrate management, budgeting and proposal preparation skills acquired through regular specialized higher education and/or documented experience. Screening begins December 31, 1992 and continues until the position is filled. Send applications to: Prof. Matthew Mashikian, University of Connecticut, Institute of Materials Science, U-136, 97 N. Eagleville Rd., Storrs, CT 06269-3136. We encourage applications from under-represented groups, including minorities, women and people with disabilities. (Search #3A92).

Communication Systems at Arizona State University. The Department of Electrical Engineering is seeking a faculty member (Assistant, Associate, or Full Professor, tenure-track) in the area of Communication Systems. Senior-level applicants having expertise in Digital Communication Theory, Optical Communications, Spread Spectrum Communications, Modulation Theory, or Information Theory arâe particularly encouraged. Applicants must hold an earned doctorate in Electrical Engineering or a related discipline, have a distinguished record of research and teaching accomplishments, and show evidence of leadership in sponsored research and professional service. Arizona State University is the fifth largest U.S. university, with approximately 30,000 undergraduate and 12,000 graduate students. The College of Engineering and Applied Sciences at ASU is established among the leading up-and-coming engineering graduate schools. The Department of Electrical Engineering has approximately 850 undergraduate and 470 graduate students, and research expenditures of \$3M per year. Communication Systems engineering at ASU benefits from a strong base of telecommunication industry in the Phoenix area and active programs in related disciplines within the Department of Electrical Engineering and the Telecommunications Research Center. Applicants should send a letter of application, a resume with publication list, and the addresses and telephone numbers of three references to: Faculty Search Committee; Department of Electrical Engineering; Arizona State University; Tempe, AZ 85287-5706. The first application deadline is 15 January 1993; thereafter, applications will be reviewed on the 15th of each month until the position is filled. Arizona State University is an Equal Opportunity Employer. The Department encourages diversity among its applicants.

California State University, Fresno Electrical and Computer Engineering Department is seeking applicants for one or more expected positions beginning in August 1993. An earned Ph.D. and B.S. Degree in Electrical or Computer Engineering are required for appointment at all professorial ranks. For lecturers, appointment will depend on qualifications. The successful candidate may be expected to teach courses, develop curricula and laboratories in accordance with his/her expertise in one of the following areas: 1) discrete and integrated electronic circuits, solid state devices, IC design and fabrication. 2) continuous and discrete control systems, intelligent control, intelligent sensors. The exact assignment is dependent upon departmental needs and the background of the individual. Candidates with teaching and industrial experience will be given preference. U.S. Citizenship or permanent residence is required. Send applications to: Dr. Medhat Ibrahim, Chairman, Dept of Electrical & Computer Engineering, California State University, Fresno, CA 93740-0094. Electrical & Computer Engineering is a strong, high quality program at CSU Fresno with approximately 450 students currently enrolled. The department enjoys an excellent reputation throughout the high-tech industries of California and the West. CSU Fresno is an Equal Opportunity/Affirmative Action Employer. When authorized the positions are expected to remain open until filled.

California State University, Northridge, is accepting applications for Dean, Engineering and Computer Science, available June 1993. The School is comprised of 4 departments with approximately 70 full-time faculty, 2,000 undergraduates and 700 graduate students. Undergraduate degrees in both Engineering and Computer Science are accredited. Allocates and manages resources and, with the faculty, maintains and improves quality of instruction. Requires earned doctorate in related discipline; qualification for appointment within School at advanced rank; and at least 3 years experience in academic administration, including resource and academic personnel management, at or above the level of department chair or its equivalent. Salary dependent on qualifications. Submit letter of application, resume and names of 3 references to be received no later than February 1, 1993, to: Chair, SECS Search & Screen Committee; c/o V.P., Academic Affairs (ACAF); California State University, Northridge; 18111 Nordhoff Street; Northridge, CA 91330. Fax (818) 885-4691 or E-Mail DBIANCHI@VAX.CSUN.EDU. Equal Opportunity/Affirmative Action, Title IX, Sections 503 & 504 Employer.

Electrical Engineer. Position available in fall 1993 for electrical engineer interested in assisting in a non-traditional B.S.E. engineering program with electrical and mechanical concentrations. Ph.D. desired. Preference given to applicant with teaching experience in communications, signal processing, digital system design and solid state electronics. Possible involvement in teaching basic sciences and general education courses. Present engineering enrollment is 110 with 6 FTE faculty plus technician. Review of applications begins January 1, 1993 and will continue until position is filled. Messiah College is affiliated with the Brethren in Christ Church and seeks candidates committed to an evangelical expression of the Christian faith. Applicants must complete Messiah's employment application form, which will be sent to inquirers. Women and Minorities strongly encouraged to apply. Direct inquiries, with vita, to Dr. James Scroggin, Chair, Engineering Department, Messiah College, Grantham, PA 17027, (717) 766-2511.

Senior Scientist/Program Manager - Iowa State University. The Center for Nondestructive Evaluation at Iowa State University is seeking an individual with expertise in theoretical and experimental ultrasonics to conduct an active program of applied research and development in the field of ultrasonic nondestructive evaluation (NDE), including the definition of and initiation of new research projects. In addition, this individual may serve as program manager for the industrial/university cooperative research program in the Center for NDE. The position requires a Ph.D. in theoretical and applied mechanics, physics or electrical engineering, plus ten years of research experience, including project management. Salary is commensurate with qualifications. Applicants should send a complete resume plus the names and addresses of three references to: Ames Laboratory/IPRT Personnel Office, 127 Spedding Hall, Iowa State University, Ames, IA 50011. An equal opportunity/affirmative action employer.

The Johns Hopkins University - Postdoctoral Position. The Department of Computer Science of The Johns Hopkins Engineering School, the Department of Radiology of The Johns Hopkins Medical School, and the IBM T.J. Watson Research Center invite applications for a two-year postdoctoral position to participate in a research project dealing with minimally invasive surgical techniques using robotics and visualization. The first six months will be spent at the IBM T.J. Watson Research Center and the following eighteen months at The Johns Hopkins University. Applicants who have research expertise in robotics, graphics, or related fields are of particular interest. Applicants should send a resume and the names of three references to Prof. Gerald M. Masson, Chair, Department of Computer Science, The Johns Hopkins University, Baltimore, Maryland 21218 (e-mail: masson@cs.jhu.edu). The Johns Hopkins University is an equal opportunity and affirmative action employer.

New Mexico State University. Tenure and non-tenure faculty positions at all professorial and instructor levels are expected to be available with the Department of Electrical and Computer Engineering. A Ph.D. in EE or ECE is required for the professorial ranks. Instructor positions are available for qualified doctoral students. Applications from all areas in EE or ECE will be considered. Send them to Dr. Don Merrill, Head ECE, Box 30001, Dept. 3-0, New Mexico State University, Las Cruces, NM 88003. Initial Screening will begin Dec. 10, 1992, however, applications will continue to be accepted and evaluated until positions are filled. Positions contingent on eligibility for employment in the U.S. New Mexico State University is an equal opportunity/affirmative action employer.

Director. The University of Minnesota seeks a Director for its Charles Babbage Institute (CBI). CBI is a contemporary history and archives center which focuses on the history of information processing since 1935. Qualifications include a record of research, teaching, and publication, administrative experience suitable to direct an institute of this sort; ability to work with the community; and a record of fund raising. The closing date is January 15, 1993. For more information, contact Dr. Walter H. Johnson, Office of the Dean, Institute of Technology, University of Minnesota, 117 Pleasant Street SE. Minneapolis, MN 55455. The University of Minnesota is an equal opportunity educator and employer.

University of Houston. The Department of Electrical and Computer Engineering invites applica-

CLASSIFIED EMPLOYMENT OPPORTUNITIES

tions for tenure-track positions in computer engineering. Research areas of particular interest include Parallel High Performance Computing. Parallel Architectures and Computer Networks. Applications are also welcome in all primary fields of electrical engineering. Please send resumes to Dr. J.C. Wolfe, Department of Electrical and Computer Engineering. University of Houston, Houston, TX 77204-4793. An Equal Opportunity Employer.

Government/Industry Positions Open

Engineer, Design. Resp. for R&D & development of CMOS circuit technology for next-generation programmable system devices (PSD's) integrating high-density memory (EPROM, SRAM) with PLD's & logic for user configurable multiprocessor & multicontroller applications. Also resp. for developing new circuit techniques to improve speed & power perf.; for all phases of development from product definition through production release. Reqs. Ph.D. in Elec. Engrg. Reqs. doctoral rsrch concen. in DPTL (differential pass transistor logic) CMOS I.C. design. Also reqs. knowl. of high-speed & low power CMOS logic & circuit design; knowl. of state-of-the-art logic circuit design techniques incl. DPTL & Domino logic; knowl. of high-density memory circuits & programmable logic devices; knowl. of state-of-the-art CAD software for IC design; and knowl. of layout design. Salary: $55,000/yr. Job & intrvw. site: Fremont, CA. Send ad with resume to Marilyn Pedro, Sr. H.R. Admin., 47280 Kato Road, Fremont, CA 94538 not later than Dec. 10, 1992. Must have legal right to work.

Software Engineer for Dayton, Ohio research and development contractor. Will research, design and develop computer software systems, in conjunction with hardware product development for military and research and development applications, working particularly with artificial intelligence techniques, with applications to networking with and interoperability of systems. Will also work in particular with object oriented concepts of computer simulation, analyzes software requirements to determine feasibility of design within time and cost constraints. Consults with hardware engineers and other engineering staff to evaluate interface between hardware and software and operational and performance requirements of overall system. Formulates and designs software system, using scientific analysis and mathematical models to predict and measure outcome and consequences of design. Develops and directs software system testing procedures, programming and documentation. Consults with customer concerning maintenance of software system. Will coordinate installation of software system. No experience required in above duties but applicants will qualify with an MS in Computer Science or engineering and one year of programmer analyst experience working with artificial intelligence including a minimum of one years experience with X-Windows; C++, LISP, and Prolog languages, as well as with Sun-workstations and IBM PC hardware. 40 hours/week, 8:00 AM – 5:00 PM, Mon.–Fri., $697.00/week. Must have proof of legal authority to work indefinitely in the United States. Send resume in duplicate (no calls) to J. Davies, JO#1338545, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, Ohio 43216.

Staff Officer. The Computer Science and Telecommunications Board of the National Research Council is seeking a Staff Officer to plan and develop projects, meetings, and workshops; maintain liaison with researchers, policy makers, program officers, institutions, and sponsors; support committee and other program meetings, write background papers, contribute to deliberations, provide follow up preparations; and prepare/revise status reports, technical summaries, and interim/final project reports. Please note this is neither an MIS/operational position nor is it a computer science research position. Position requires an MA/MS or equivalent in computer science, computer engineering, management (with technical undergraduate degree), public policy; or a related field, at least 4 years experience in computer science, computer and communications technology, and computer and communications applications in industry and government; and strong familiarity with PC technology and design and implementation issues associated with large and complex systems. Please send a resume/cv, brief writing sample, and the names of three references in confidence to: NRC/CPSMA/CSTB, HA 560 (RH), 2101 Constitution Avenue, N.W., Washington, D.C. 20418. EOE.

Electrical Engineer II: Acts independently and may supervise Electrical Engineer I to perform analysis of auxiliary electrical power systems which have been installed in nuclear power plants to determine whether such systems are capable of performing appropriate functions under various emergency situations including station blackout and loss of coolant. Calculates and analyzes heat loss of such electrical nuclear power plant systems to determine whether equipment meets specifications and is capable of performance under various heat variables. Performs Engineering Change Modifications and reviews drawings to assure conformity with engineering and nuclear power plant safety regulations. Determines appropriate sizes of fuses to be installed in safety related control circuits and insure fuse integrity with upstream protective devices. Uses ELMS computer software to monitor the auxiliary power system. Requires M.S. or Master of Engineering with a major in Electrical Engineering. Also requires one year experience in the job to be performed or one year experience as an Electrical Engineer. If experience in related field, entire experience must include performance of all duties as described above at an entry level position which does not require acting independently and supervision. Education to include completion of one course in each of the following: Electric Machine; Power System Analysis; Linear System Design; Advanced Network Theory; Instrument and Control; and, Fiber Optics Communications. Hours: 8:00 a.m. - 5:00 p.m. 40 hours per week at $17.70 per hour salary. Must have proof of legal authority to work permanently in the U.S. Please send resume to: Illinois Department of Employment Security, 401 S. State St. - 3 South, Chicago, IL 60605, Attn: Len Boksa, Ref. #V-IL 6015-B, No Calls, 2 copies of your resume required, An Employer Paid Ad.

Engineer, Head Media. Resp. for working closely with vendors to specify and procure advanced magnetic recording heads and media. Test and evaluate the heads and media to determine their suitability for use in future disk drive products. Determine characteristics required of heads and media to work with new concepts in disk drive design, specifically partial response channels, MR heads, contact or near-contact recording. Develop measurement techniques to evaluate magnetic components for use in drive designs. Req. Ph.D. degree in Electrical Engineering. Also requires knowledge of: design and measurement of disk noise and nonlinearities; along-track and across-track noise correlations; micromagnetic analysis of advanced magnetic disks and heads; including multilayered thin films and magnetoresistive heads; digital signal processing and its uses in recording systems, and of fabrication and characterization of magnetic physics and materials, including metallic thin films and ferrites. Salary: $56,000/yr. Job/intvw, site: Milpitas, CA. Send ad w/resume to Job #MD21717, P.O. Box 9560, Sacramento, CA 95823-0560 no later than January 5, 1993.

Systems Engineer - To model, study and perform detailed analysis of the various components of switching systems communications networks, to evaluate them using detailed modeling techniques and advanced mathematical tools and to predict accurately the performance impacts of various design alternatives on the system when the parameters are changed. To develop and propose new models to evaluate performance of new systems and suggest methods of improving hardware, software reliability and throughput. To examine existing baseline processes and study them to identify possible areas of improvement and recommend specific steps in order to increase efficiency and output. Requires a PhD Degree in Systems Science and Mathematics with graduate research in advanced mathematical analysis and tools, modeling and simulation of real time systems, use of software tools, UNIX, VMS, DOS Operating Systems, computer languages: Fortran, Pascal, C, Lisp, Prolog, Basic and Cobol. Applicant must also have 2 years experience in the job offered or 2 years as a Research Assistant in the Systems Science and Mathematics Department at a college university with research directed in the areas of analysis, modeling and simulation of discrete time nonlinear systems. 40 hours per week, (work schedule: 7:45 am to 4:30 pm). Salary is $60,000.00 per year. Must have proof of legal authorization to work in the U.S. Send resume in duplicate (No Calls) to J. Davies, Ohio Bureau of Employment Services, P.O. Box 1618, J.O. #1333210, Columbus, Ohio 43216. An equal opportunity employer.

Manager, Ride and Show Safety - Manage development & maintenance of rides & projects; monitor documentation to ensure compliance with State regulations and ASTM F24; ensure that: preventative maintenance programs are being followed, tasks completed timely, comprehensive NDT program is developed and implemented. BS EE or equiv. + 2 yrs exp in job or 6 yrs exp. in managerial position within theme park, ride maintenance environment; exp in design of ride & theme show layout to include utilization of electronic circuitry; exp in electrical, electronic & mechanical (pneumatic & hydraulic systems, welding) equipment performance, reliability, & safety systems; excellent working knowledge of operational exp. of theme park rides and attractions; exp. in water park attractions; knowledge of ASTM standards & other applicable laws required; 40 hrs, $47k/yr. Please send resume & ad to: Job Service of Florida, 3421 Lawton Rd, Orlando, FL 32803 Attn: JO#FL0674496.

Engineer, Senior Device: Model & characterize state of the art high speed devices & circuits for VLSI design. Knowledge of device physics & modeling instrumentation. Knowledge of device modeling such as Gummel-Pool & Spice Level 1/2/3 models. Knowledge of numerical techniques, 3-D simulators for advanced CMOS & BJT devices. Knowledge of submicron device simulation & Quantum transport modeling. Able to program in C, Fortran, Basic & Pascal on Unix, VM/CMS & VMS. Jobsite: Santa Clara, CA. Ph.D. i/EE or equiv. required. Salary: $56,700/yr. 40 hrs./wk. Clip ad & submit w/resume to: IEEE Spectrum, Box 12-1, 345 E. 47th St., N.Y., N.Y. 10017 before January 5, 1993.

Research Associate to investigate optoelectronic technologies for parallel digital optical logic and interconnection architectures. Must have at least one year experience in integrated surface-emitting laser-based switching and logic device technology as documented by significant publications in referred journals. $28,000/yr, 40 hrs/wk. Must have completed at least all course work toward a Ph.D. in Electrical Engineering. Submit resumes to the NM Dept. of Labor, 501 Mountain NE, Albuquerque, NM 87102. CC#1001. JO#426378.

Electrical Engineer: Beautiful Southern Oregon! Hunting, fishing, boating, skiing, Shakespeare, arts, good schools and medical facilities. A 15 person multi-discipline consulting firm servicing commercial and industrial building industries. Minimum 4 years experience electrical engineering for lighting, power distribution, communications systems for building design. Excellent verbal and written communication skills a must. Computer skills a plus. Excellent benefits and competitive salary. Oregon State P.E. license or be able to obtain within 6 months. Resume, references and salary history to Marquess & Associates, Inc., P.O. Box 490, Medford, Oregon 97501.

Manager of Technology Research–High-technology company located in the Northwest is looking for a Manager of Technology Research. Qualified applicant must possess: Master of Science degree in Physics; 7 years of experience developing analog and digital wireless telecommunication equipment such as AMPS, TACS, or Dual Mode cellular mobile station or base station to include 5 years experience in system architecture design and/or five years of project manage-

ment experience for wireless telecommunication products, doing system definition and specification work. Will analyze and assess industrial technical activities and trends in the areas of telecommunications with focus on wireless and cellular/personal communication areas to forecast product needs and opportunities. Will perform system analysis, definition, specification and architecture design for cellular/personal communication products. Will evaluate digital communication technologies proposed in the cellular/personal communication systems and make recommendations. Will employ digital communication technologies such as TDMA, CDMA and engineering of DSP operations. Will attend intercompany meetings to set industry standards for wireless telecommunication systems. 40 hours [redacted] week, plus overtime as needed. Salary: $68,600 per year. Mail resume by December 31, 1992, to: Employment Security Department, E&T Division, Job # 346174-S Post Office Box 9046, Olympia, WA 98507-9046.

Government/Industry Positions Wanted

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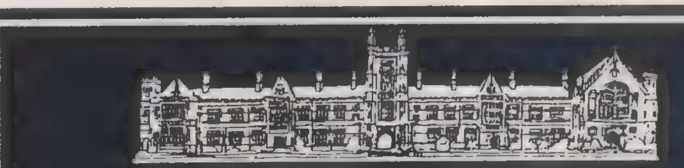

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Faculty of Engineering

CHAIR OF ELECTRICAL ENGINEERING
Reference No: C37/01

Applications [redacted] sought for appointment as Professor of Electrical Engineering. This vacancy arises from the retirement of Professor Messerle.
The Department has [redacted] other established Chair in [redacted] general [redacted] electronics and information systems. There are currently [redacted] academic [redacted] and the Department is currently in an expansion phase. A new building extension will be completed at the end [redacted] this year.
Strong and active postgraduate programs and research are in place with significant funding attracted from the research agencies as [redacted] as from industry.
The successful applicant will be expected to provide research and academic leadership encompassing one or more of the areas of current interest: power system generation, distribution, protection; electrical machines; power electronics and drives; control (classical, optimal, nonlinear, stochastic, automation); circuit theory (network synthesis, "analogue" filter design); electrical education and teaching techniques; plasma technology, magnetohydrodynamics; and optical fibre technology. The Department is looking for strong [redacted] to [redacted] energy and power industries and contributions to both [redacted] undergraduate program and the area of professional continuing education.
Salary will be at the [redacted] of A$77,900 per annum with [redacted] possibility of [redacted] market loading of at least 15%.
Further information may be obtained from Professor Trevor Cole, Head, Department of Electrical Engineering, ph (61 2) 692 2682, fax (61 2) 692 2682 or (61 2) 692 3847. Further general information is also available from [redacted] Association of Commonwealth Universities, 36 Gordon Square, London, WC1H – OPF.
It is anticipated that interviews for the Chair will be held within [redacted] months of the closing date.
The University [redacted] the right to appoint by invitation and not to proceed [redacted] any appointment for financial [redacted] other reasons.

Method of application: four copies of the application, quoting Reference No, including curriculum vitae, list [redacted] publications and the names, addresses and FAX nos of [redacted] least three and not more than [redacted] referees should [redacted] lodged by **10 December 1992** with The Assistant Registrar (Appointments), Staff Office (K07), University of Sydney NSW 2006, Australia (fax (61 2) 692 4316) from whom a detailed statement of information concerning the Chair should be obtained.

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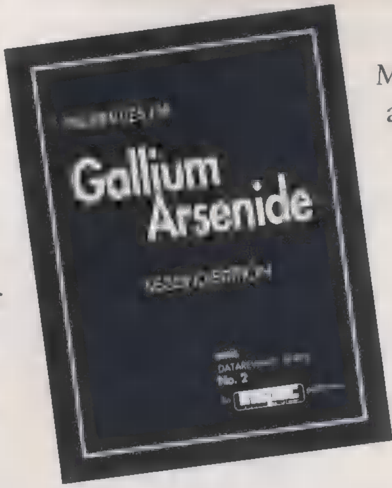

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Scanning
The Institute

H. Troy Nagle chosen 1993 President-Elect

H. Troy Nagle, professor of electrical and computer engineering at North Carolina State University in Raleigh, was elected the IEEE's 1993 President-Elect. Nagle will assume the IEEE presidency on Jan. 1, 1994. The other candidate nominated by the IEEE Board of Directors for the office was Edward C. Bertnolli, professor of electrical engineering at North Dakota State University in Fargo.

Nagle joined the IEEE in 1966, was named a Fellow in 1983, served on the Board of Directors from 1987 to 1990, and was Vice President-Technical Activities, 1989-90.

Suttle to succeed Fanning

W. Thomas Suttle was named staff director for professional activities and will head the IEEE's U.S. Activities office in Washington, D.C., effective Jan. 1. He succeeds Leo C. Fanning, retiring after holding the post for the past 13 of his 17 years with the IEEE.

Suttle holds two degrees. The University of the South at Sewanee, Tenn., awarded him a bachelor's with honors. The School of Advanced International Studies of Johns Hopkins University granted him a master's degree in international studies. From 1971 to 1973, he was an intelligence officer with the U.S. Air Force and in 1977 he joined the IEEE staff. He has held a variety of management positions and is currently associate staff director of professional activities.

Christiansen to retire

Donald Christiansen, editor and publisher of *IEEE Spectrum*, will retire Feb. 1, 1993. Christiansen, who joined the magazine's staff as editor in 1971, also serves as editor-in-chief of THE INSTITUTE. Under Christiansen's stewardship, *Spectrum* has won a National Magazine Award three times, and has been a finalist in the contest 10 times in the last 14 years. A search for Christiansen's successor is under way.

Congressional Fellows sought

The IEEE-U.S. Activities plans to award at least two Congressional Fellowships for the 1993-94 term. It is looking for electrical and electronics engineers and scientists in allied areas to serve on the staff of Senators, Representatives, or Congressional committees. The goal is to help government make better use of scientific and technical knowledge, and to educate the scientific community in the public policy-setting process.

Fellows will be selected for technical competence, ability to serve in a public environment, and evidence of service to the Institute and to the profession. The Fellow must be a U.S. citizen at the time of selection and must have been in the IEEE at Member grade or higher for at least four years. Further information and application forms are available. *Contact W. Thomas Suttle, 202-785-0017; fax, 202-785-0835; or write to Secretary, Congressional Fellows Program, IEEE, 1828 L St., N.W., Washington, D.C. 20036.*

Science and math for kids

A new source book of opportunities helps people who want to encourage youngsters to pursue careers in science, mathematics, or technology. The directory describes 35 programs, along with procedures for getting involved, and is free to potential volunteers. Each program needs mentors, tutors, and role models.

Publication of the directory is cosponsored by IEEE-U.S. Activities and Engineers for Education, a nonprofit association of 45 engineering societies with the goal of making U.S. students the best in the world at science and mathematics by the year 2000. Copies of *Directory of Volunteer Opportunities* may be obtained by calling Engineers for Education at 800-489-0348.

Coming
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"TECHNOLOGY '93," *IEEE Spectrum*'s annual January overview of actual hardware and software will spotlight advances and trends in the fields covered by the magazine.

Each article will consist of a brief discussion by a recognized expert in the field of the most significant developments and a report by a *Spectrum* editor of major developments, recent and impending. Specific hardware and software will be cited by manufacturer wherever called for.

Experts for the issue and their areas are: Capers Jones, Software Productivity Research Inc., software; Harvey M. Glickenstein, Thomas K. Dyer Inc., transportation; Vinton Cerf, Corporation for National Research Initiatives, data communications; James Martin, Eli Lilly & Co., biomedical engineering; Helen M. Wood, National Oceanic and Atmospheric Administration, large computers; Tom Lyon, Sun Microsystems Computer Corp., PCs and workstations; Bennet Kobb, New Signals Press Research, telecommunications; Malcolm Currie, Hughes Aircraft Co., aerospace and military; Fumio Harashima, University of Tokyo, industrial electronics; Tsugio Makimoto and Takaaki Hagiwara, Hitachi Ltd., solid state; Michael A. Isnardi, David Sarnoff Research Center, consumer electronics; and Johan Schoukens, Brussels Free University, test and measurement.

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